# RECORDS

OF

# THE GEOLOGICAL SURVEY OF INDIA.

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# THE GEOLOGICAL SURVEY OF INDIA

## VOLUME XXXVII

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# RECORDS OF

# THE GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1908. [October.

## GENERAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA FOR THE YEAR 1907. BY SIR T. H. HOLLAND, K.C.I.E., D.SC., F.R.S., *Director*.

### CONTENTS.

## INTRODUCTION.

THIS Report records the operations conducted by the Geological Survey of India during the calendar year 1907, and briefly reviews the principal results obtained by the officers' researches; but these are more fully described in separate papers published in the *Records* and *Memoirs*. A special statement is published in this Part of the *Records* summarising the returns for Mineral Production during 1907, while a list is appended of the concessions granted for prospecting and mining in lands of which the mineral rights are held by the Government of India. There has been satisfactory progress in production and an extraordinary increase in the activity of prospectors, mainly inspired by the phenomenal success of those who were already prepared to meet the increased demand for manganese-ore and coal. This increase in prospecting has thrown additional work on the staff at headquarters, where enquiries for information during 1907 far outnumbered those that were felt to be a serious tax on the officers' time during previous years. Among the officers who shared this work, the most considerable burden fell on Mr. C. S. Middlemiss, who was in charge of the office routine duties from March till the end of the year.

2. The statement of Mineral Production now published is the fourth issued since the publication of the Review for 1898—1903[1]. The next statement will form part of the Quinquennial Review for the period 1904—08.

[1] *Records, Geol. Surv. Ind.*, XXXII, Part I.

## DISPOSITION LIST.

3. During the period under report the officers of the Department were employed as follows:—

*Superintendents.*

MR. T. H. D. LATOUCHE. Returned from Burma on the 27th May 1907. Granted 3 months' privilege leave and in continuation special leave for 3 months with effect from the 5th July 1907.

MR. C. S. MIDDLEMISS. At headquarters from the 1st March 1907, in charge of office and preparing memoir on the Kangra earthquake.

MR. H. H. HAYDEN. At headquarters in charge of office up to the 28th February 1907. Services placed at the disposal of the Foreign Office with effect from the afternoon of the 28th February 1907.

*Assistant Superintendents.*

MR. P. N. DATTA. Returned from the Central Provinces on the 2nd April 1907, and deputed to the same area for continuation of the Geological Survey of the Chanda and Raipur districts on the 18th November 1907.

MR. E. VREDENBURG. At headquarters as Palæontologist up to the 14th April 1907. Granted 3 months' privilege leave with effect from the 15th April 1907. Returned from leave and resumed the duties of Palæontologist with effect from the 8th July 1907.

MR. L. L. FERMOR. At headquarters as Curator up to the 23rd August 1907. Deputed to continue the manganese investigation and left for the field on the 23rd August 1907.

MR. G. E. PILGRIM. Returned from leave on the 20th July 1907. Deputed to the Bugti

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| | Hills, Baluchistan, on the 17th November 1907. |
| MR. G. H. TIPPER. | Returned from the North-West Frontier Province on the 28th April 1907. Appointed Officiating Palæontologist from 15th April 1907 to the 7th July 1907. Granted 3 months' privilege leave and in continuation 9 months' study leave with effect from the 19th July 1907. |
| MR. H. WALKER. | Returned to headquarters from the field on the 30th April 1907. Appointed Curator on the 24th August 1907. |
| MR. E. H. PASCOE. | Returned from Burma on the 27th May 1907. Re-posted to Burma in connection with the petroleum industry, and left for the field on the 10th November 1907. |
| MR. K. A. K. HALLOWES. | Returned to headquarters from the Singhbhum district on the 1st June 1907. Deputed to the Singhbhum district for the continued examination of the copper-bearing belt on the 30th November 1907. |
| MR. G. DE P. COTTER. | Returned from Burma on the 26th May 1907. Re-posted to Burma in connection with the petroleum industry, and left for the field on the 10th November 1907. |
| MR. J. COGGIN BROWN. | Returned to headquarters from Burma on the 27th May 1907. Deputed to Yünnan and left for the field on the 12th November 1907. |
| MR. J. J. A. PAGE. | Deputed to make a survey of the tin-ore deposits in Southern Burma on the 1st February 1907. Returned to headquarters from Burma on the 30th May 1907. Re-posted to South Burma to continue his investigations |

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| | of the tin deposits, and left headquarters on the 6th August 1907. |
| MR. H. C. JONES. | Deputed to Nellore, Madras, on the 15th January 1907. Returned to headquarters on the 15th March 1907. Posted to the Central India party, and left for the field on the 7th November 1907. |
| MR. A. M. HERON. | Posted to the Central India party, and left for the field on the 16th January 1907, returned to headquarters on the 30th April 1907. Re-posted to Central India for continuation of the previous seasons' work on the 7th November 1907. |
| MR. M. STUART. | Joined the Department on the 1st December 1907. |
| MR. N. D. DARU. | Joined the Department on the 4th December 1907. |

*Chemist.*

| | |
|---|---|
| DR. W. A. K. CHRISTIE. | At headquarters throughout the period under report. |

*Sub-Assistants.*

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| S. SETHU RAMA RAU. | Returned to headquarters from the field on the 11th May 1907. Posted to Mr. Pascoe's party in Burma, and left for the field on the 10th November 1907. |
| M. VINAYAK RAO. | Accompanied Mr. Jones to Nellore, Madras, and left for the field on the 15th January 1907, returned to headquarters on the 15th March 1907. Posted to Mr. Pilgrim's party in the Bugti Hills and left for the field on the 15th November 1907. |

*Assistant Curator.*

| | |
|---|---|
| MR. T. R. BLYTH. | On duty at headquarters throughout the period under report. |

## ADMINISTRATIVE CHANGES.

4. The following officers joined the Department during the period under report:—

**New officers.**

Mr. M. STUART, B.Sc. (Birmingham), F.G.S., joined on the 1st December 1907.

Mr. N. D. DARU, B.Sc., B.A. (Bom.), B.Sc. (London), A.R.S.M., Bar.-at-Law, joined on the 4th December 1907.

**Appointments.**

Mr. H. WALKER was appointed Curator with effect from the 24th August 1907.

Mr. G. H. TIPPER was appointed Officiating Palæontologist from the 15th April 1907 to the 7th July 1907, *vice* Mr. E. Vredenburg on privilege leave.

**Promotions.**

Mr. E. H. PASCOE was specially promoted to the grade of Assistant Superintendent on Rs. 500-50-1,000, with effect from the date of his confirmation.

Mr. P. N. DATTA, Assistant Superintendent, Geological Survey of India, was appointed to officiate as Superintendent, with effect from the 1st March 1907, *vice* Mr. H. H. Hayden, whose services have been placed at the disposal of the Foreign Department.

Mr. E. VREDENBURG, Assistant Superintendent, Geological Survey of India, was appointed to officiate as Superintendent with effect from the 5th July 1907, *vice* Mr. T. H. D. LaTouche, on combined leave.

**Confirmations.**

The following officers were confirmed in their appointments as Officers of the Geological Survey Department:—

Mr. E. H. PASCOE.
Mr. G. de P. COTTER.
Mr. J. C. BROWN.

**Leave.**

Mr. T. H. D. LATOUCHE was granted 3 months' privilege leave combined with 3 months' special leave with effect from the 5th July 1907.

Mr. E. VREDENBURG was granted 3 months' privilege leave with effect from the 15th April 1907.

Mr. G. H. TIPPER was granted 3 months' privilege leave and in continuation study leave for 9 months with effect from the 19th July 1907.

Mr. H. B. W. GARRICK was granted 2 months and 13 days' privilege leave. Extended 'on medical certificate' 6 months with effect from the 29th July 1907.

**Study Leave.**

5. Two of the officers took advantage of the new rules providing for extra furlough to study in Europe. Mr. G. E. Pilgrim completed on July 18th a course of training in Palæontology at the Cambridge University under Mr. H. Woods and at the British Museum under Dr. C. W. Andrews. A portion of the research work done during this leave, being a study of some new *Suidæ* from Baluchistan, has already been published in *Records*, Vol. XXXVI, Part 1; the remainder will be included in a memoir on the Persian Gulf now in the press.

Mr. G. H. Tipper took combined privilege and study leave from the 19th July, and entered for a course of training also in Palæontology at Cambridge. Mr. Tipper has undertaken, as a part of his work, a study of the Liassic fossils of Baluchistan.

**Research Students and Apprentices.**

6. The scheme, first outlined in the General Report for 1903-04,[1] for training post-graduate students in practical Geology and Mineralogy, has been continued with very satisfactory results. Two students were under training during 1907, one holding a scholarship from the Bengal Government, and the other being granted a scholarship by the Central Provinces Administration. After training in the Laboratory and Museum in determinative work, both students were deputed to accompany Mr. Fermor on field duty in the Central Provinces and Chota Nagpur. For some years the Professorship of Geology in the Presidency College has been held by a Geological Survey Officer, and until recently the work has been no more than could be undertaken by the officer in charge of the office routine duties at headquarters; but the geological classes have now grown considerably, students are turning to geological subjects for a professional career, and these, with the apprentices sent from the Provinces and States, deserve the full attention of a special officer. It is proposed, therefore, as soon as sufficient accommodation can be obtained in the office, to place the educational aspect of the Geological Survey work on a systematic basis, in order that a recognised course of training may carry with it, for the worthy student, a diploma of competency. On account of the limited and imperfect arrangements for geological teaching under most of the Indian Universities, we have been compelled hitherto to accept

[1] *Records., Geol. Surv. Ind*, *Pt.* 2, *p* 133.

graduates in science who have had little or no grounding in geological principles; and, for this reason, it has been considered advisable so far not to make the post-graduate training on the Geological Survey a formal course. But it should now be possible to obtain graduates able to make profitable use of the large collections in the Museum and Library at headquarters, which are exceptionally well equipped for the requirements of the research student.

## Obituary.

7. I have regretfully to record the deaths of two distinguished retired members of the Department—Mr. T. W. Hughes-Hughes and Mr. C. L. Griesbach, C.I.E.

**T. W. H. Hughes—1907.**

Mr. Hughes joined the Geological Survey in 1862, and was on the roll of officers for 32 years. Among the list of 44 memoirs and papers published during his service the most prominent are his reports on the Peninsular coalfields. His memoirs and maps of Jherria, Bokaro, Karharbari, Deoghar, Karanpura, Itkuri, Daltonganj and the Wardha valley fields have been superseded by subsequent work only in additional detail, made possible by later exploitation and mining. In 1884 and 1885 his services were transferred to the Public Works Department to superintend the collieries at Warora and Umaria; afterwards his services were lent to the Hyderabad (Deccan) Company, and still later he superintended the tin-prospecting operations in South Burma. In 1892 he acted as Director during Dr. King's absence on leave, and it was during the following season, while on duty in Central India, that the lamentable accident occurred, which left him blind for the rest of his life.

**C. L. Griesbach—1907.**

8. Mr. C. L. Griesbach joined the Survey in 1878, and his first two seasons of field-work were occupied in mapping the Ramkola and Tatapani coalfields in the Sone basin; for this work he was selected on account of his previous experience on the Gondwana (Karroo) formations of South Africa. In the following hot weather, however, he was sent to the Central Himalayas of Kumaon and Hundes, and then commenced the survey of the remarkable series of fossiliferous strata lying to the north of the central crystalline axis of the Himalayan range, which has since proved to be of such remarkable interest to geological science. In 1880 Mr. Griesbach accompanied the Afghan Expedition, and, in addition to geological work on previously unknown ground, his military work was specially mentioned in the despatches.

## VOLUME XXXVI.

Petrological Study of some Rocks from the Hill Tracts, Vizagapatam district, Madras Presidency, by T. L. Walker, M.A., Ph.D., and W. H. Collins.

Nepheline Syenites from the Hill Tracts of Vizagapatam district, Madras Presidency, by T. L. Walker, M.A., Ph.D.

The Stratigraphical Position of the Gangamopteris-Beds of Kashmir, by H. H. Hayden, B.A., F.G.S.

On a Volcanic Outburst of Late Tertiary Age in South Hsenwi, N. Shan States, by T. H. D. LaTouche, B.A., F.G.S.

Description of some new *Suidæ* from the Bugti Hills, Baluchistan, by Guy E. Pilgrim, B.Sc., F.G.S.

Permo-Carboniferous Plants from Kashmir, by A. C. Seward, F.R.S.

The Mineral Production of India during 1906, by T. H. Holland, F.R.S.

The Ammonites of the Bagh Beds, by E. W. Vredenburg, A.R.S.M., A.R.C.S., F.G.S.

Miscellaneous Notes on :—A Bituminous Limestone from the Vindhyan Series, Jodhpur State. Wavellite from the Singhbhum district, Bengal. Corundum from the Singhbhum district, Bengal. Apatite-magnetite-rock from the Singhbhum district, Bengal. Note on the Occurrence of Orpiment on the Shankalpa Glacier, Kumaon. Note on the Tatkan area: blocks 21—26: N. Yenangyaung. Fossils from the Miocene of Burma. Some Triassic Ammonites from Baluchistan.

**Memoirs.** The following Memoirs were published during the year:—

The Geology of the Provinces of Tsang and Ü. in Central Tibet, by H. H. Hayden, B.A., B.E., F.G.S.

The Fauna of the Himalayan Muschelkalk, by Professor Carl Diener, Ph.D., *Palæontologia Indica,* Series XV, Volume V, Memoir No. 2.

## LIBRARY.

10. The additions to the Library during the period 1st January 1907 to 31st December 1907, amounted to 3,140 volumes. Of the books received this year 1,027 were acquired by purchase and 2,113 by presentation.

## MUSEUM AND LABORATORY.

**Curator.**

11. On the 24th August 1907 Mr. H. Walker was appointed Curator of the Museum and Laboratory in the place of Mr. L. L. Fermor, who had carried on the duties with conspicuous efficiency since the 8th March 1905.

**Determinative and Chemical Work.**

12. During the year there was a great increase in the number of specimens, samples of minerals, ores and rocks referred to the Curator for determination, by extra-departmental officials and the general public. The number of specimens examined was 1,092, compared with 786 in 1906, and 782 in 1905. Out of this number 45 assays and analyses were made.

In addition to the above, estimations of the amount of silt and total salts were made in 142 samples of Indus river water. These samples were collected by Sub-Assistant M. M. Ry. Vinayak Rao from stations at Sukkur and Kotri, and are those which it was not possible to determine during the year 1906. In completion of the above enquiry, Dr. Christie has carried out investigations of average samples of the water and silt.

Work in the laboratory was greatly hampered during the year by the necessity for making various structural alterations.

**Meteorites.**

13. One Indian meteorite was recorded during the year as having fallen on May 9th, 1907, in the Ghazipur district of the United Provinces. The pieces obtained are dark-grey in colour, very chondritic, and are so friable that all have crumbled slightly during transmission to the Museum. Only one piece shows the fused crust. The Collector of Ghazipur sent three specimens of a total weight of 2,324 grammes. Two other pieces weighing respectively 1,007 and 5,372 grammes were kindly presented by Miss Sturmer of Kajha. The total weight of the fall which has so far come to hand is 7,705 grammes.

There is considerable variety in the localities recorded, due possibly to the scattering of fragments after explosion, but the nearest important village *Chainpur* is taken as the name of the fall.

Two pieces of another stony meteorite, belonging to a fall dated December 15th, 1906, near *Vishnupur*, Bankura district, Bengal, have been presented to the Museum by Dr. G. T. Walker, F.R.S., Director-General of Observatories.

## MINERALOGY.

**New Group of Manganates.**

16. During the course of his exhaustive study of the manganese-ore deposits of India, which will shortly be described in a memoir now in the press, Mr. L. L. Fermor has made special studies of certain new minerals that have been discovered. In studying the constitution and relations of the ill-defined species psilomelane, he concludes that there is now enough material to distinguish as a special family the manganates of barium, lead and other bases, corresponding to the hypothetical acid $H_4 Mn O_5$. In this family occur, besides the amorphous *psilomelane*, the fibrous lead-manganate described by W. Lindgren and W. F. Hillebrand in 1904[1] as *coronadite*, and the barium-iron manganate, *hollandite*, originally found at Kajli-dongri, Central India, and afterwards obtained at various localities in the Central Provinces and largely worked at Sitapar, Chhindwara district, for export as an ore of manganese. The chemical constitution of these minerals is discussed in a special paper published in *Records*, Vol. XXXVI, Part 4.

## PETROLOGY.

**Jadeite deposits, Myitkyina district.**

17. An interesting investigation of the valuable jadeite-deposits in the Myitkyina district, Upper Burma, was undertaken, at my suggestion, by Dr. A. W. G. Bleeck.

The full results are published as a separate paper in volume XXXVI of the *Records*. Dr. Bleeck examined the jadeite occurrences at three localities in the Kachin hills, namely, Tawmaw, Hwéka and Mamon. At Tawmaw he describes the mineral as occurring in a metamorphosed igneous dyke intruded into serpentine. He concludes that the jadeite is the result of the metamorphism of an albite-nepheline rock originally forming the dyke, both minerals being found together with the jadeite at Tawmaw. The change would be represented chemically as follows :—

$$Na\ Al\ Si\ O_4\ \text{(Nepheline)} + Na\ Al\ Si_3\ O_8\ \text{(Albite)} = 2\ Na\ Al\ Si_2\ O_6\ \text{(2 Jadeite)}.$$

Under certain conditions of crystallization nepheline-albite rock might form, while, under conditions of high pressure during consolidation or after, jadeite, which has a much lower molecular

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[1] *Amer. Journ. Sci.*, 4th Ser., XVIII, 448—451.

volume, would be produced, the residual molecule forming albite or nepheline according to which molecule was in excess in the original magma. In the neighbourhood of Tawmaw occur various crystalline schists which are intruded into by granite. The granite is traversed by veins of aplite and pegmatite (products probably of the same great eruption) and masses of crystalline limestone are found associated with the granitic rocks, containing various minerals characteristic of contact-metamorphism. The relations of the granite to the crystalline limestone in this region are similar to those of Mandalay Hill, Sagyin, and Mogok in the Ruby Mines district, where similar contact minerals, including the different varieties of corundum, are found in the metamorphosed limestone. The crystalline schists include chloritic schists with well-formed crystals of magnetite, aclinolite schists and glaucophane schists. These are all regarded by Dr. Bleeck as the metamorphic products of basic igneous rocks affected by the adjoining granitic intrusions. The serpentines form a long narrow ridge, flanked on one or both sides by saussuritic-gabbros, saussuritic glaucophane-schists and chloritic schists. These rocks are traversed by granite and veins of quartz: all the rocks are regarded as genetically related, and as the results of the differentiation of the same magma, which gave rise successively to the peridotites, gabbros, nepheline-albite (jadeite) rock and the siliceous end-products of granite and quartz

**Relation to Tertiary Sediments.**

18. In addition to the crystalline and igneous rocks there are exposures in this area of a sedimentary series, consisting of sandstones and conglomerates, with shaly layers and thin coal-seams. These beds were regarded by Dr. F. Noetling,[1] as miocene in age, and, although no fossils of stratigraphical value were found, Dr. Bleeck accepts the formation as belonging to some stage of the Tertiary system ; but he differs radically from Dr. Noetling's views as to the relative ages of this sedimentary series and the serpentine-jadeite complex. Dr. Noetling[2] stated that the Tertiary strata are pierced by the basic igneous rocks that include the jadeite veins ; but Dr. Bleeck finds that the eruptives, including the jadeite, are prominently represented among the boulders in the Tertiary conglomerate, and thus must have become weathered to contribute to the Tertiary

[1] *Records Geol. Surv. Ind.*, XXVI, 1893, p. 28.
[2] *Loc. cit.*, p. 28.

sediments. These conglomerates are worked at Hweka for the jadeite-boulders, which are also collected among the recent alluvial deposits of the Uru river near Mamon.

**Rubies of Naniazeik.**

19. Dr. Bleeck also took the opportunity, while in the Myitkyina district, of examining the ruby-bearing deposits near Naniazeik. In all essential respects the occurrence resembles the well-known area of Mogok described by Professor J. W. Judd and Mr. C. Barrington Brown.[1]

Rubies are found in the soil and alluvial accumulations around the village of Naniazeik as well as in the river-gravels on the eastern slopes of the mountain ranges between Naniazeik and Manwe. This mountain range is composed mainly of granite and crystalline limestone, the latter having obtained its crystalline characters probably as stated before, through the intrusion of the granite. The limestone contains various minerals as the result of contact-metamorphism—garnet, spinel, chondrodite, graphite, forsterite, and other accessories, besides the valuable rubies and sapphires. The contact of granite and marble, exposed on the road from Sikaw to Naniazeik, shows the granite to assume a pressure structure near the margin, and to contain large quantities of phlogopite, which is a prominent mineral also on the marble side of the contact. The marbles, when freshly broken, have the characteristic evil smell of many limestones charged with introgenous organic matter. The marble is thus probably the result of the metamorphism of an ordinary sedimentary limestone of chemico-organic origin, but no data are obtainable to determine its age. Dr. Bleeck's paper is published in *Records*, Vol. XXXVI, Part 3.

## PALÆONTOLOGY.

**Palæontologist.**

20. Mr. G. H. Tipper acted as Palæontologist during Mr. Vredenburg's absence on privilege leave from the 15th April to the 7th July 1907, but for the rest of the year the latter officer held the appointment, and, in addition to the research work which has already been published in part in the *Records*, Mr. Vredenburg has made considerable progress in arranging the rich undescribed materials

[1] "The Rubies of Burma and associated Minerals." *Phil. Trans. Roy. Soc.*, Vol. 187, 1896.

from the Tertiary beds of Western India, collected by various officers during past years and left unclassified in the office. The corals and echinoids have been sifted and the molluscan collections are now in course of arrangement.

**Lower Eocene Mollusca.**

21. The Mollusca from the Ranikot stage (Lower Eocene) are being described by Messrs. Cossmann and Pissaro of Paris, and the first instalment of their elaborate work, describing about 100 species of cephalopods and gastropods, has been received and translated by Mr. Vredenburg for publication in the *Palæontologia Indica.* On receipt of the description of the lamellibranchs it will be possible to estimate the stratigraphical significance of this work.

**Intertrappean fossils in the Cretaceous of Baluchistan.**

22. Mr. Vredenburg has also sorted the valuable collections of Upper Cretaceous fossils from Baluchistan, and, during the course of this work, has discovered that the well-known freshwater gastropod *Physa Prinsepii* Sow. so characteristic of the freshwater beds intercalated in the Deccan Traps, occurs in marine beds containing Upper Cretaceous (Maestrichtian) ammonites. An account of this occurrence has been published as a special paper in the *Records* (Vol. XXXV, p. 114, see also *Records*, Vol. XXXVI, p. 178, foot-note). The specimens have been found in the collections from the Des Valley as well as in those from Mazar Drik and all the essential features of the species are unmistakeably displayed. The shells, therefore, must belong to individuals that were carried out to sea from the land on which the Intertrappean beds were laid down. The associated marine fossils fix the age of the beds with reasonable precision as upper Maestrichtian, and we have thus an important piece of evidence to fix the age of the great Deccan Trap eruptions more precisely than was possible before.

**Nummulitic rocks of the Palana coalfield.**

23. A small collection of fossils obtained by Mr. Jervis from the Palana coalfield in the Bikaner State, Rajputana, has enabled Mr. Vredenburg to show that the coal-bearing series in this area corresponds to the Laki series of Lutetian age.

In reviewing the fragmentary evidence regarding other post-Gondwana coalfields in India, Mr. Vredenburg concludes that in most cases there is a balance of evidence in favour of a Laki age; he points out that there are many doubtful features in the

evidences adduced for the existence of Cretaceous and of post-Nummulitic coal. This point, if confirmed, will give a valuable horizon for stratigraphical work, especially in Assam and Burma, where there are so many isolated small coal-bearing basins.

**Study of Ostrea multicostata, Deshayes.**

24. Among the Palana fossils occur specimens of *Ostrea multicostata*, Deshayes, a species about which there has been considerable confusion in geological literature. Mr. Vredenburg, having examined the descriptions of this and other close-ribbed *Ostreæ*, comes to the following conclusions:—

(1) The previous citations of *O. multicostata* in India refer to the following six species: (*a*) *O. angulata*, J. de C. Sowerby (Upper Nari and Gaj); (*b*) *O. latimarginata*, Vredenburg (=*O. flabellula*, Lamk., according to Sowerby; Upper Gaj); (*c*) *O. cubitus*, Deshayes (Lower Nari); (*d*) *Gryphaea Esterhazyi*, von Pavay (age uncertain); (*e*) *Ostrea turkestanensis*, Romanowski. (Nari in the lower Zhob valley); (*f*) *Exogyra* sp. (probably Cretaceous).

(2) The specimen regarded as eocene and figured in 1883 by d'Archiac and Haime as *Ostrea multicostata*, Desh., var., again figured under the same name, but as a miocene form, in both editions of the Manual (1879 and 1893), regarded, by Mayer-Eymar, in 1871, as the type of an eocene species *O. orientalis*, is an incomplete, and consequently unsatisfactory specimen of the Aquitanian species *O. angulata*, J. de C. Sowerby.

(3) The true *O. multicostata* occurs in India in the middle eocene, and characterises the same beds as in Egypt and Southern Europe.

(4) The other close-ribbed species of *Ostrea sensu stricto* in the Indian Tertiary, are (*a*) *O. Fraasi*, Mayer-Eymar (Lower Nari), (*b*) *O.* n. sp. related to *O. Fraasi* (uppermost Gaj), (*c*) *O. digitalina*, Eichwald, var. *Rholfsi*, Fuchs, (Hinglaj series in the beds with *O. Virleti*), (*d*) *O. promensis*, Noetling [Yenangyaung series with (*e*) *O. peguensis*, Noetl., probably identical with *O. Virleti*].

(5) The Burdigalian stage, whose existence in Asia had been ascertained only over a very limited area, is found to be widely distributed in India, and includes the greater

part of the Hinglaj series in the Mekran, the Yenangyaung series in Burma, and possibly the Cuddalore series, and other Tertiary beds in the coastal regions of the Peninsula.

**Cretaceous Foraminifera.**

25. Mr. Vredenburg has continued his researches on the fossil *Foraminifera* in continuation of the work reviewed in the General Report for 1906 (*Records*, XXXV, p. 16). He has now examined the collections of *Orbitoides* from the Cretaceous beds. These are found to agree generically, and in some cases specifically, with the forms known in Europe, while their stratigraphical distribution follows the European sequence. The Indian localities of the specimens examined are the Mari hills, and the province of Jhalawan in Baluchistan, Western Sind, the Suleiman range, and the Coromandel coast; the specimens occurring amongst Mr. Hayden's collections from Tibet have also been examined. It is in Dr. Noetling's collections from the Mari hills that the zonal sequence has been established in greatest detail. Mr. Vredenburg has identified a number of the associated fossils from this series, constituting the principal basis of the correlation which he has adopted.

In a general way three horizons are recognised—a lower one characterised principally by *O. media*, a middle one with *O. socialis*, *O. Hollandi* and *Omphalocyclus macropora*, and an upper one with *O. minor*. The lower zone is regarded by Mr. Vredenburg as principally Campanian, the two others as Maestrichtian. *Orbitoides media* and *Omphalocyclus macropora* are the two commonest species, and neither of them is entirely restricted to the zones above mentioned, *Omphalocyclus macropora* descending into the lower zone, and *Orbitoides media* rising into the middle one, but in a general way, *Omphalocyclus* is the newer form, rising into a horizon never reached by *O. media*, and *vice versâ*.

Mr. Vredenburg has noticed that in all the Indian occurrences *Omphalocyclus macropora* is represented by both forms megaspheric and microspheric. The existence of the dimorphism has for the first time been established only quite lately (December 1907) by Professor A. Silvestri in his study of the specimens occurring both at Maestricht and in the neighbourhood of Palermo.[1] The constitution of the megasphere in the specimens from Baluchistan

[1] *Atti della Pontifica Acc. N. Lincei*, LXI, pp. 17—26.

is identical with that of the Maestricht specimens figured by Silvestri. It is suggested that the close resemblance between *Orbitoides socialis* and the genus *Lepidocyclina* may be a case of "convergence."

**Correlation of Baluchistan and Coromandel Cretaceous.**

26. The identification of the fairly numerous ammonites from the Mari Hills and Jhalawan has enabled Mr. Vredenburg to attempt a correlation of the Baluchistan beds with the Ariyalur of Southern India: both the Valudayur and Trigonoarca beds are regarded as the equivalents of the lower part only of the ammonite-bearing beds of Baluchistan, those which have generally been spoken of as the "Hemipneustes-beds", and include the bulk of the two lower *Orbitoides*-bearing zones. The uppermost ammonite-bearing zone of Baluchistan (of which the leading fossils are *Sphenodiscus Ubaghsi*, *Indoceras baluchistanense* and *Cardita subcomplanata*) does not appear to be represented by any fossiliferous beds in the type region of the Coromandel. It possibly corresponds with the unfossiliferous sands which, in the Trichinopoly area, intervene between the fossiliferous Ariayalur and Niniyur beds; but the stratigraphy of the Niniyur series has not been investigated sufficiently closely to allow of a strict correlation, though it certainly corresponds, in part at least, with the uppermost Cretaceous beds of Baluchistan and Sind, the "Pab sandstones" or "*Cardita Beaumonti* beds". In Western Persia, in the districts of which the geology has been unravelled by de Morgan and by Douvillé,[1] the "Echinoid beds" of these authors correspond principally with the Hemipneustes-beds of Baluchistan, while the "Cerithium-beds" are mainly the equivalents of the zone of *Cardita subcomplanata*. Mr. Vredenburg has suggested that the latter zone, unknown in the Trichinopoly and Pondicherri areas, may be represented further north along the east coast by the fluvio-marine intertrappeans of Rajamahendri, several of whose leading fossils, such as *Cerithium Stoddardi*, *Irania fusiformis* and *Physa Prinsepii*, are among the characteristic forms of the zone of *Cardita subcomplanata* in Baluchistan and Persia.

In consequence of the definite reference to well-known horizons resulting from a study of the Baluchistan fossils, Mr. Vredenburg is of opinion that the term "Pathanian," introduced by Dr. Noetling, becomes unnecessary as it clashes with the long established name "Maestrichtian" (or "Dordonian").

[1] Mission scientifique en Perse: Mollusques fossiles, 1904.

**Cretaceous Pseudofucoids near Fort Munro.**

27. Mr. Vredenburg has studied a number of interesting specimens collected in the Suleiman Range by Mr. H. J. Maynard, I.C.S., the Revd. Mr. Lee-Mayer, Major F. W. Pirrie and Captain F. C. Nicolas. Among these are various markings of the kind well known in the Flysch formations of Europe, and formerly ascribed with doubt to algæ, but now generally regarded as tracks and trails of marine animals. The specimens of this nature from the neighbourhood of Fort Munro were obtained in rocks that have been correlated with the Pab series of uppermost Cretaceous age in Jhalawan, Baluchistan. Some of the markings are of a kind that might be made by various kinds of animals, and thus they show a general sameness of character in rocks of various ages, from Cambrian and possibly pre-Cambrian times to the miocene. Although these structures are consequently of no assistance in determining stratigraphical horizons, they are interesting because they characterise the so-called *Flysch* facies of formations in various periods, and the occurrence of similar structures in the Vindhyan sandstones of Peninsular India suggests that this peculiar formation has also originated *à la Flysch*; to this, perhaps, is due its mysterious barrenness from the palæontologist's point of view. Mr. Vredenburg's description of the material from Fort Munro is published in *Records*, Vol. XXXVI, Part 4.

**Napeng (Rhaetic) beds: Northern Shan States.**

28. The collections made during the progress of the survey of the Northern Shan States by Messrs. La Touche and Datta from the Napeng shales have been examined and described by Miss Maud Healey, and the results will appear as a special Memoir in the *Palæontologia Indica* (New Series, Vol. II, *Mem.* No. 4). The work has presented considerable difficulty, owing partly to the state of preservation of the fossils, which are almost without exception mere casts, and partly to the fact that the great majority of them are lammellibranchs, with no trace of the rich cephalopod or brachiopod fauna of the Himalayan Mesozoics. The stratigraphical position also of the beds, in which the fossils occur, could not be determined with accuracy, since they are found in isolated patches on the surface of the Shan Plateau, and their relations to the rocks both above and below are very obscure.

Although the general facies of the fauna seemed in the first instance to Messrs. LaTouche and Datta to indicate a Mesozoic

horizon for these fossils, the recognition of a *Conocardium* among them by Dr. Noetling pointed to a much earlier position, and they were consequently referred with much doubt to the Devonian period in my predecessor's General Report for 1899-1900 (p. 85), especially as the stratigraphical evidence available seemed to point in that direction. Subsequently Dr. Noetling, on visiting the localities, found what he considered to be numerous specimens of Triassic *Myophoriæ, etc.*, among the fossils (Gen. Rep. 1900-01, pp. 16, 19); but again, on discovering further specimens of *Conocardium*, he reverted to his original opinion, and the beds were referred to in the General Report for 1901-02 (p. 24) as undoubted Devonians.

The researches of Miss Healey have now placed it beyond doubt that the Napeng beds are Rhætic, since they contain numerous specimens of the characteristic Rhætic form *Pteria* (= *Avicula*) *contorta*, in addition to *Grammatodon Lycettii* and *Gervillia præcursor*, while many other specimens closely resemble Rhætic species. It is, however, a fact that the Palæozoic genera *Conocardium* and *Modiolopsis* are represented, in addition to *Palæoneilo*, which is also found in the Devonian shales of Wetwin.

**Exotic Blocks of Malla Johar, Kumaon.**

29. In the Central Himalayas of the Kumaon division the younger Mesozoic beds that form the complicated syncline of the Chitichun area are capped in places by massive limestone blocks, which either appear to rest conformably on, or are embedded in, the soft Jurassic shales. They are partly of Palæozoic and partly of Lower Mesozoic age, and the anomalous position of these blocks above younger strata has given rise to a considerable amount of controversy. On account of the way in which they are weathered out as picturesque crags, rising in abrupt pinnacles above the younger rocks around, similar occurrences in the Carpathians and Alps have long been known as *Klippen*, and with reference to their origin, as *exotic blocks*.

The first comprehensive account of the geology of the Central Himalayas of Kumaon is due to the late C. L. Griesbach (*Mem. Geol. Surv. Ind.*, XXIII). In a short paper referring to the preliminary results of a special expedition undertaken by himself, Professor C. Diener and Mr. C. S. Middlemiss in 1892, Mr. Griesbach referred especially to these exotic blocks (*Rec. Geol. Surv. Ind.*, XXVI, p. 22), and explained their occurrence by faulting. Professor C. Diener (*Mem. Geol. Surv. Ind.*, XXVIII, pp. 1—27) subsequently gave a

general account of the fossils found during the 1892 expedition, and discussed more fully the origin of the exotic blocks, generally endorsing Griesbach's views. The late Dr. von Krafft extended the survey of the frontier district between Hundes and Malla Johar in 1900, and published a special memoir (*Mem. Geol. Surv. Ind.*, XXXII, Part III) on the exotic blocks, which, as remarked by Diener in his memoir on the "Cephalopoda of the Triassic limestone crags of Chitichun" (*Pal. Ind.*, XV, Vol. II. Pt. II, Chap. 3), he considered to differ from the "Klippen" of Europe in being intimately connected with igneous extrusions; but von Krafft admitted the difficulty of offering a satisfactory explanation of where the blocks had come from and how they had reached their present position.

30. Professor Diener has now completed a detailed description of the Upper Triassic and Liassic fossils obtained mainly by von Krafft, and has applied his results to the theories in existence regarding the origin of these remarkable phenomena. Professor Diener's results prove to be of most unusual interest. He confirms von Krafft's conclusion that the Permian and Triassic beds in the blocks belong to facies quite different to those of the beds of corresponding age found in the normal sections in this area: the former von Krafft termed the *Tibetan* and the latter the *Himalayan* series. Professor Diener now notices that, in the carnic and liassic beds of the Tibetan series, there are remarkable agreements with their homotaxial equivalents in the Mediterranean region, the agreement being often lithological as well as faunistic. The fossils of Lower Triassic and Muschelkalk age in the exotic blocks show small affinities with the Alpine Trias, and more nearly resemble those of the Himalayan region; but there is still a certain lithological contrast. But the carnic fossils of the Tibetan series differ largely from those of the Himalayan series, and show very close affinities to the zones of *Trachyceras Aonoides* and *Tropites subbullatus* in the Eastern Alps. Among the liassic fossils of the Tibetan series Mediterranean affinities are still more marked, the identity of species being almost complete in some blocks; in fact, the difference between the liassic faunas of Wurtemberg or England and the Alps is even more conspicuous than between the latter and the lower liassic fossils of the Tibetan series found in the exotic blocks. It is generally accepted that to the north of the main region of the Himalaya there existed a part of the ancient ocean, known as *Tethys*, which was in direct communication with the European area,

and while local peculiarities existed in Triassic times sufficient to distinguish the assemblages of fossils of the Tibetan series from those of the Mediterranean region, the conditions in these widely separated parts of *Tethys* were almost obliterated in liassic times. It is assumed that the exotic blocks of Malla Johar were brought from somewhere further north in the Tibetan region; but we still are unable to identify the region, and this discovery by Professor Diener of the remarkable agreement between the "Tibetan" and Alpine carnic and liassic fossils adds considerably to the interest of the question. Professor Diener's memoir is now in the press and will be issued as Vol. I, Part I, Series XV, of the *Palæontologia Indica.*

**Cambrian fossils: Spiti.**

31. The description of the Cambrian fossils collected in the Parahio and Pin valleys in Spiti during the years 1898-1901, has recently been received from Mr. F. R. Cowper Reed and is of very considerable interest. The fauna comprises ten genera of trilobites, five genera of brachiopods, one of pteropods (*Hyolithes*), one echinoderm (*Eocystites*) and one zoophyte (*Coscinocyathus*). The trilobites constitute by far the greatest proportion of the fauna, and embrace thirty-one species, of which almost all are new, only one being definitely identified with a hitherto described species; while three others are either identical with, or closely allied to, previously known forms. Next in importance come the brachiopods, of which there are 14 species, only ten being sufficiently well preserved for specific determination: of these ten species, six are new and four closely allied to, or identical with, North American forms.

In the Parahio valley, whence most of the specimens were obtained, six horizons have been recognised; and it is a remarkable fact that the fauna of each horizon is peculiar to it, no single species having been found in any two horizons. The lowest horizon is characterised by the presence of small brachiopods (*Lingulella* and *Billingsella*) and the remaining five by trilobites, of which two genera, *Ptychoparia* and *Olenus*, largely predominate; the latter genus is restricted to the uppermost horizon, whilst *Ptychoparia* is absent from this, but occurs in all the remaining four.

The only trilobite that has been definitely identified with a known species is *Redlichia Noetlingi* Redl., a single specimen of which was found in the Pin valley near Muth. It has not been

found in the Parahio sections, and its position in the sequence is not completely established, but it is almost certainly not higher than that of the lowest horizon with *Billingsella* and *Lingulella.* The presence in Spiti of this well-known Salt Range species is of great interest, since it is the only form known to be common to these two areas. Its presence, however, leads Mr. Cowper Reed to conclude that the beds in the Pin valley, from which it was derived, are of uppermost Lower Cambrian age.

The remaining trilobites, with the exception of those found in the highest, or Olenus, horizon, as well as the brachiopods and other fossils, are remarkable for their dissimilarity to either Salt Range or European types. On the other hand, they show decided affinities to genera from the Middle Cambrian beds of Western North America; and Mr. Cowper Reed, therefore, regards them as of Middle Cambrian age, concluding that at that period Spiti formed a part of the North American province.

The highest horizon is especially characterised by the presence of the genus *Olenus* and the absence of *Ptychoparia*, and is regarded as of Upper Cambrian age.

The general conclusions arrived at by Mr. Cowper Reed, as expressed in his own words, are—

"(1) the main mass of the beds must be referred to the Middle Cambrian, and the palæontological affinities of the fossils in these beds are with the Rocky Mountain province of America;

"(2) the Lower Cambrian is probably represented in Spiti, and the sole species which it has yielded is identical with one occurring in the Eastern Salt Range;

"(3) the Upper Cambrian is found at the top of the Parahio sequence, and contains a small assemblage of fossils of indefinite affinities, but includes a member of the genus *Olenus*, thereby suggesting a connection with the northern European province."

These results have an important bearing on the classification adopted for the oldest Palæozoic systems of the Himalaya. In Spiti the trilobite beds are separated from the next overlying rock group by a marked unconformity, and the fact that the Upper Cambrian is represented by only the uppermost part of the trilobite beds leads to the inference that this system must either extend up into the overlying conglomerate and red quartzite hitherto

regarded as Ordovician, or that almost the whole of the Upper Cambrian was removed before the deposition of the latter formations. The apparent absence of this unconformity in the Garhwal and Kumaon Himalaya, and the presence below the red quartzite of a bed of limestone, regarded by Mr. Griesbach as of Ordovician age, points rather to the latter view as the correct one. The fossils from this limestone, which are now in Mr. Cowper Reed's hands, have not yet been critically examined, but it is hoped that they will enable us to define the upper limit of the Cambrian system of the Himalaya.

To find the lower limit of the system will be more difficult. The lowest known fossiliferous horizon in Spiti is that of *Redlichia Noetlingi*, which is presumably of uppermost Lower Cambrian age; consequently the rest of the system must be looked for in the underlying "red quartz shales", defined by Mr. Griesbach as the uppermost member of his Haimanta system. It seems hardly probable that the whole of the Haimanta system, which is many thousands of feet in thickness, is of Lower Cambrian age, and Mr. Cowper Reed's work thus confirms Mr. Griesbach's suggestion that his Haimantas include also pre-Cambrian beds.

**Gondwana plants: Kashmir.**

32. Progress regarding the investigation into the plant-bearing beds underlying the Zewan stage of Kashmir was reported in the General Reports for 1902-03, 1903-04 and 1906, and the state of the problem is discussed fully in Mr. Hayden's paper on "the Stratigraphical Position of the Gangamopteris beds of Kashmir[1]."

Professor A. C. Seward kindly examined the additional fossil plants collected by Mr. Hayden in 1906, and found that while the species previously recognised are generally repeated, the new material serves to confirm the previous provisional determination of a new species of *Psygmophyllum* and some imperfect remains of *Cordaites*[2]. The evidence of this new material does not affect Mr. Hayden's conclusion "that the *Gangamopteris* beds are not younger than Upper Carboniferous and may belong to the base of that subdivision, or even to the Middle Carboniferous."

A systematic survey of these beds is now being undertaken by Mr. C. S. Middlemiss, who will keep especially in view the important questions regarding the stratigraphical relationship of the

[1] *Rec. Geol. Surv. Ind.*, XXXVI, pp. 23—39, 1907.
[2] Prof. Seward's results are published in Part I of *Records*, Vol. XXXVI.

plant-bearing series to the volcanic rocks below, and the apparently conformable passage of Permian into Triassic beds above. The discovery of further representatives of the Gondwana flora will also be of the greatest interest in determining the geological age of the Peninsular coal measures.

## ECONOMIC ENQUIRIES.

### Copper.

33. During the field season 1906-07 Mr. K. A. K. Hallowes was deputed to continue his survey of the copper-bearing belt in the Singhbhum district. In consequence of the favourable results said to have been obtained in the past by prospecting operations on the area leased to the Rajdoha Company, observations were first directed with a view of finding a suitable site for diamond drilling, on the completion of the operations in progress in the Kharsawan Estate.

Mr. Hallowes reported two parallel outcrops of the copper impregnated schists striking approximately N.W.—S.E. and showing at intervals from Matigara at the south-east end of the Rajdoha property to near Rajdoha on the north-west. The copper-bearing zones and the enclosing schists dip towards the N.E. at angles varying from about 52° to 35°, and sites were selected to the north of the outcrop for later determination of the lodes by drilling. A similar survey of the copper-bearing band was made in the Dhalbhum Estate and in Suraikela.

34. The diamond-drilling accomplished during the year included—

(*a*) Kodomdiha, north of Amda in the Kharsawan State: a hole to the depth of 1,093 feet. This hole was intended to test the persistence of the lode previously cut further south at a depth of 392—404 feet. At this place the lode was about 8 feet thick, and carrying 5·102 per cent. copper;[1] it was struck by the diamond drill further north at a depth of 1,069 feet, but was there found to carry only 1·825 per cent. copper for a thickness of about one foot.

[1] Mr. Hallowes is responsible for this and the assay results quoted below.

(*b*) Regadih (Galudih), 5 miles west of Kodomdiha.

In this place a shallow hole was drilled to test the copper lodes that have been extensively quarried on the outcrop. Drilling was extended to a depth of 430 feet. Specks and stringers of copper pyrites were found at various depths from 131 feet to 294 feet; but there was nowhere a concentration of ore. The nearest approach to concentration was at a depth of 293 feet, where a portion of the core 13 inches long only gave 0·606 per cent. of copper.

(*c*) Landup (Nadup) near Kalimati in the Dhalbhum Estate. Drilling was continued to a depth of 465 feet, but the only concentration of ore was found at about 197—198 feet, where for a thickness of 14 inches the lode yielded 3·335 per cent. copper.

So far as they go these borings demonstrate a drawback that is a common failing among the ore-deposits in Peninsular India, namely, abundant material widely disseminated instead of concentrated in a way that would permit of economic exploitation. The diffused character of the ore accounts for the apparently extensive nature of the ancient workings that mark the outcrop. The conspicuous, highly-coloured carbonates probably occurred scattered over wide zones; but no one now knows how much copper was obtained from these quarrying operations, of which no historical record is preserved. Another feature shown by the diamond-drilling is the general constancy in dip of the copper-bearing bands; had there been more disturbance of the rocks, however, there might possibly have been developed the compensating feature of richer concentration.

The most favourable results obtained in 1907 were those at 392—404 feet in the Kodomdiha Drill-hole; but it is impossible to say without further work along the strike whether this is a mere local swelling of the lode or a fair representation of it in this locality. Similarly, the less favourable results elsewhere may give an unfair idea of the deposits tested: it will be the business of those who take up concessions to extend the Geological Survey work by further prospecting where, as at Kodomdiha, the expenditure of more money would be a reasonable venture.

Further borings are now in progress near Matigara and Laukisra and the completion of these will complete the programme as far as the Geological Survey is concerned.

I would like to take this opportunity of recording my appreciation of the high quality of work done by Mr. M. J. Gallaghan, who was sent out by the Sullivan Company to conduct the work of drilling.

A large quantity of material has been collected and on the completion of the work in the Laboratory a full description of the lodes and associated rocks will be published.

## Gold.

**The Namma, Northern Shan States.**

35. The small gold-field on the Namma, a tributary of the Salween some 50 miles east of Lashio, was visited by Messrs. LaTouche and Brown. An abortive attempt had been made during the previous year to recover the gold in this field by means of a steam dredger, but the character of the deposit was found to be unfitted for this method of exploitation. It consists of gravel and boulders imbedded in a stiff clay, hardened by the deposition of calcareous tufa derived from thick beds of limestone forming the sides of the valley, and not sufficiently loose to enable the buckets of the dredger to excavate it. Some form of hydraulic mining would seem to be more suitable and promising, as there is an abundant supply of water (which could easily be obtained at high pressure) available on the spot.

The gold appears to have come from the ancient rocks forming the crest of the range on the north side of the valley, for the lower slopes on this side, and the whole of the southern side of the valley, are composed of limestone.

## Manganese-ore.

**South India.**

36. After handing over charge of the Museum and Laboratory to Mr. Walker on the 23rd August, Mr. L. L. Fermor was deputed to South India to inspect certain recently opened-up deposits of manganese-ore with a view of completing the data for his memoir on Indian manganese. The deposits examined included those of Sandur in the Bellary district, Chitaldrug, Kadur, Tumkur and Shimoga in Mysore, and various occurrences in the Belgaum district.

37. Most of the deposits in South India differ in an essential character from those of Nagpur and adjacent districts in the

Central Provinces: in the latter area the ore-bodies now appear to be an integral part of the crystalline complex, although it is probable that they have attained their present character as bodies composed mainly of clean oxides by alteration of manganese-silicates, possibly through the agency of subterranean water of meteoric origin; in South India, however, as in parts of Jubbulpore, the ore-deposits are more superficial, and appear to be residual products from the surface alteration of the various lithological elements that constitute the Dharwar system of schists. The manganese-ores occur irregularly associated with lithomarges, ochres and wads, sometimes taking the form of nodules and concretions, and sometimes of more extensive masses. The Kumsi deposit in the Shimoga district of Mysore is an exceptionally large example of such surface accumulations of ore; but most of them are of small depth and comparatively low in quality.

**Sandur.**

38. Enormous quantities of the so-called superficial kind occur also in the Sandur State, where they were noticed long ago by R. Bruce Foote,[1] who also described the great syncline of Dharwar schists forming the Sandur hills. Mr. Fermor concludes that the manganese and associated iron-ores are formed as weather-products from hematitic schists and slates similar to those on which the ore-deposits now lie. In spite, however, of the fact that the ore-bodies must be described as superficial, there is no doubt that millions of tons are available on the Ramandrug plateau: it has yet to be proved that the ores of the Central Provinces will be more lasting than some of these so-called superficial deposits, for those that in the Central Provinces form a part of the crystalline complex probably pass down into silicates unsuitable for the requirements of the metallurgist. We have no idea as to the depths to which the pure oxides extend in any case. Like the so-called superficial deposits, many of these have obviously greater resources than will be affected by mining operations in the near future, and their owners are not at present sufficiently anxious about the distant future to share with Government the expense of testing their ore-bodies by diamond-drilling. Mr. Fermor's report on the occurrences in Sandur State has been sent to the General Sandur Mining Company, which has leased the principal deposits.

[1] Geology of the Bellary District, *Mem. Geol. Surv. Ind.* XXV, p. 194, 1895.

**Inspection of Mines, Central Provinces.**

39. Mr. Fermor was also deputed to the Central Provinces during December to make a second inspection of the manganese-ore quarries. The rapid development that followed the rise of prices in 1906, and the accessibility of the ore-bodies, have attracted a certain number of workers whose experience in the methods of mining hardly enable them to carry out the covenants made in their leases and licenses; it was partly in order to assist such workers with advice and criticism, partly to ensure development without unnecessary waste and destruction of the ore-bodies, that these informal inspections have been ordered.

During his last tour Mr. Fermor inspected the following deposits :—

*Chhindwara district :—*

Gowari Warhona, Sitapar, Gaimukh, Lakhanwara and Kachi Dhana, all worked by the Indian Manganese Company, Limited.

*Nagpur district :—*

Kodegaon, worked by the Indian Manganese Company; Gumgaon and Lohdongri, worked by the Central Provinces Prospecting Syndicate; Kacharwahi and Mandri, worked by the Central India Mining Company.

*Bhandara district :—*

Miragpur, worked by the Central India Mining Company; Hatora and Chikla, worked by the Central Provinces Prospecting Syndicate.

During his work Mr. Fermor received, as before, the courteous assistance of the Managers, and his report has been submitted to the Central Provinces Administration for communication to the Companies concerned. The criticisms made indicate a general improvement in the system of operations, an improvement that is the natural outcome of prosperity and consequent ability to entertain more highly qualified Managers. The disadvantagee due to opencast workings, that were developed in the initial stages, before the Companies were assured of success, are now being generally recognised, and work is being planned for underground mining. The recent fall in prices will naturally limit the operations in a large number of cases, but a reasonable rest after the feverish rush to meet the heavy demands for ore that prevailed last year will not be wholly disadvantageous to the industry.

**Mining Association.**

40. The formation of the Central Provinces Mining Association is an incident welcomed by all interested in the progress of the manganese-mining industry; the recently settled question of adjusting the royalty charges to meet the rapid and great variations in ore-values is but one of the many problems, bearing on the industry, in which a representative Association can assist the aims of Government to maintain conditions equitable to the mining community, as well as to the previously established interests of other tax-payers.

## Petroleum.

**Upper Burma.**

41. With the assistance of Mr. G. de P. Cotter, Mr. E. H. Pascoe was deputed for a second season to Burma for the supervision and further examination of the oil-fields. Besides reports to the Burma Government regarding the local regulations, the geological work included:

**South Yenangyaung field.**

42. (i) *An examination of the faulted area to the south of Beme village in the Yenangyaung Oil-field.* Indications of faulting had been observed by Mr. Davies of the Burma Oil Co., and on examination Mr. Pascoe established a fault of some magnitude extending obliquely N. N. E. to S. S. W. across the outcrops of the various Miocene beds from close to the crest of the anticline for some distance into the Pliocene. Other adjacent faults — probably minor ones — render the elucidation of this area difficult in the extreme. Whether the large fault extends completely across the Miocene outcrop or ends in the numerous veins of mud which have honeycombed the crest-beds, is a point which, it is hoped, will be cleared up by further work. There appears to be some connection between this faulting and the failure to find anything in appreciable quantities but gas south of Beme.

**Minbu.**

43. (ii) *A survey of the Minbu Hills on a scale of 8 inches to a mile.* This anticline of Miocene and Pliocene beds is one of great interest from a scientific point of view. Slightly asymmetric, and sharply folded, it has been very extensively denuded and its deeper structure laid bare. There are many comparatively large faults, one of which appears to coincide with the line of mud-volcanoes near the town of Minbu. In several

spots within the 20 demarcated square-mile blocks, boring for oil has been undertaken, but with little success. Although there is certainly room for further testing, it is very improbable that any large or richly yielding oil-field will ever be established here. An account of this area will be published later on.

**Wetchok.**

44. (iii) *Examination of a recently discovered Miocene outcrop near Wetchok, east of Yenangyaung.* Only the topmost beds of the Miocene are exposed here, and the fold is in the form of a gentle elliptic dome, the longer axis of which runs in the usual direction of Miocene anticlines in Burma, *viz.*, N. N. W. to S. S. E. There are several faults within the area, but the presence of a red alluvial deposit renders the tracing of them and estimation of their magnitude, matters of great difficulty. From the oil-winner's point of view the promising nature of the gentle fold is more or less nullified by the presence of faults, the small vertical depth of Miocene exposed, and the distance of the area from what has been termed the "oil-belt." A paper on this area is to be published shortly.

**Yenangyaung.**

45 (iv) *Commencement of a resurvey of the Yenangyaung Oil-field.* Two beds of marine fossils belonging to separate horizons and a bed containing a new variety of *Batissa*, were discovered. Several small faults not indicated in Dr. Noetling's published map, were found round the margin of the field, and it is chiefly for the mapping of these and the investigation of their effect upon neighbouring wells that a second survey has been undertaken.

**Yenangyat.**

46. Mr. Cotter spent November and December 1906 with Mr. Pascoe examining the Yenangyaung Oil-field and the method of digging and drilling for oil. January he spent on the Yenangyat field, mapping the eastern and western boundaries of the Miocene outcrop north and south of block 67. The main features of interest here proved to be the narrowing of the Miocene outcrop (due apparently to sharper folding) and the number of ferruginous conglomerate bands on the western flank of the anticline. These bands contain both fossil-wood and selenite, in consequence of which difficulty was experienced in establishing a definite boundary between the Miocene and Pliocene. Mr. Cotter was enabled to confirm Mr. Grimes' and Mr. Pascoe's observations on the inversion of the anticlinal fold here.

**Singu.**

47. In February Mr. Cotter paid a visit to the Singu Oil-field and among other fossils found a new species of *Dendrophyllia*, which was also found by Mr. Pascoe at Minbu. This coral is described in a paper published in *Records*, Vol. XXXVI, Part 3.

**Taungtha.**

48. March was spent by Mr. Cotter in surveying and mapping Taungtha Hill. This anticline of Miocene and Pliocene is saddle-shaped, the crest sinking in the centre between two crest-maxima. Dips are very steep, especially on the eastern flank, and the beds appear to be considerably disturbed and faulted. Owing to this and the distance of the area from the "oil-belt", prospecting would not be very promising. Details of this region are published in *Records*, Vol. XXXVI, Part 3.

**Tatkan.**

49. In April he examined the Yenangyaung blocks around Tatkan, between Singu and Yenangyaung, and pronounced unfavourably upon this tract. He was unable to identify any well-defined anticline here, and agrees with Mr. Grimes in considering the beds to consist of nothing but Pliocene.

## Salt.

**Rajputana.**

50. Besides reforming the methods and equipment of the Laboratory, Dr. W. A. K. Christie, the Chemist, has been engaged mainly in the examination of brines and river-waters from Rajputana. The investigations into the salt-resources of the Sambhar Lake described in the General Report for 1903-04 and 1905 left us in a state of uncertainty about (*a*) the balance of effect due to the artificial manufacture of pure salt and the annual additions of chloride and other sodium salts brought in by the rivers, (*b*) the origin of the large quantities of salt within the drainage basin. Arrangements have been made for the annual sampling of the lake-brine and of subterranean brine from various parts of the lake-bed. Samples of the inflowing "fresh" water during the monsoon are also being collected. It will require some years probably to demonstrate any change in the resources of the Lake due to the opposed agents of loss and gain; but it is hoped that the system now organised for annual sampling and the great precision

adopted in analysis will, in a few years, afford data of the greatest value in gauging the prospects of the industry, as well as in estimating the age and nature of the processes by which Sambhar reached its present degree of salinity.

51. To account for the large quantities of salt in the many isolated basins in the Rajputana highlands, I have suggested the action of the strong south-west winds which blow into the desert region from the salt incrusted Rann of Cutch during the dry hot months that precede the monsoon rains in each year. These winds are very inconstant in velocity, but very constant in general direction, and all movements of sand and salt towards the north-east are positive, until the first fall of rain in June or July washes the accumulated salt-dust into the lowest part of each isolated rock-basin, forming the many small salt-lakes in the desert, where Sambhar, though the largest still above the sandy mantle, is but one of many. To test this theory Dr. Christie has designed an ingenious set of instruments for sampling the desert winds during the hot weather. His results will be awaited with interest, as it is obvious that reliable support of the theory must affect our notions generally regarding the salt-deposits of desert regions, which are in general regions of indraught during hot dry seasons, when the salt crystals can break up into the finest dust. As desert conditions are often so marked in the rocks that accompany the older rock-salt deposits, a theory of this kind, if established, would also affect our notions regarding the origin of such deposits. But it is dangerous obviously to speculate on secondary issues while the theory itself is under trial.

## ECONOMIC SURVEYS.

### Silver-Lead.

**Bawdwin, Northern Shan States.**

52. The ancient silver-lead mines of Bawdwin-gyi (Great Bawdwin) in Tawng-peng, one of the lesser Shan States, were visited by Messrs. LaTouche and Brown, who studied respectively the geology and mineralogy of that interesting locality. These mines were worked by Chinese from Yunnan for a very long period until about 50 years ago, when they were deserted, and traces of their activity are everywhere apparent, notably in

the numerous galleries driven into the hill-sides for the extraction of the ore, and in the enormous heaps of lead-slag which were thrown away after smelting out the portion of the lead containing the bulk of the silver. A Company has been formed for the purpose of exploiting these slags, and is now engaged in laying a steam tramway to the spot in order to bring the material to a convenient locality for smelting.

The ores occur in a zone of intense disturbance, caused by one or more great overthrust faults traversing the rocks, which are felspathic grits and rhyolitic tuffs, probably of Cambrian age. They consist for the most part of argentiferous galena and zinc-blende, with a small quantity of copper-pyrites in minute granules. The crushing and fissuring of the rocks has enabled water or vapours impregnated with mineral solutions to percolate through the mass, the metallic ores replacing by metasomatic action the felspar and other rock-forming minerals originally present. An account of the geology and mineralogy of the locality is now ready for publication.

## Tin.

53. Mr. J. J. A. Page was deputed in February to make a survey of the tin-mining areas in the Mergui district, mainly with a view of assisting the Local Government in the administration of the industry. He was occupied until May with a preliminary examination of the ground, and, after examining at headquarters the data collected during this tour, made a preliminary report, and commenced a more detailed examination of the district from August to the end of the year.

The country is thickly covered with jungle and decomposition products which effectually conceal the rocks over great areas, while the means of communication being still in a primitive condition, exploratory work was necessarily slow.

54. So far as the geological observations go, no facts were obtained to disturb the general views previously held regarding the structure of the country. The principal hill-ranges, with a N.—S. trend, are mainly composed of granite, with flanking hills cut-out largely of unfossiliferous schists, slates, sandstones and quartzites. The granites appear to be intrusive into the sedimentary rocks, and are exposed in a series of bosses that do not form a continuous

outcrop. There appear to be more than one generation of granitic rocks, and they are traversed by quartz-porphyry dykes. The sedimentary rocks are provisionally referred to the so-called Mergui series, but it is impossible to determine their relationship to the adjoining Moulmein series, which includes Carboniferous limestones; hence their true geological age is not certainly known. Isolated patches of strata, probably Tertiary in age, are found resting unconformably on the highly inclined Mergui slates and quartzites. The coal-bearing occurrences of these rocks in the Tenasserim valley have been described already by Mr. P. N. Bose, under[1] the local name of the Tendau group.

The country is largely covered with laterite and recent alluvial deposits.

55. The only tin-ore worked is cassiterite, which is widely distributed throughout the district, and is invariably found near the granitic hills. The mineral is found under the following four conditions:—

(1) *As a constituent of decomposed pegmatite rich in tourmaline and muscovite, known locally as "Kra".* This material is found at Yaungwa, at several points along the road to Inner Bôkpyin, at Yengan, Migyaungchaung, Manoron and Yamon. *Kra* was found in the hills east of Mawton, just north of the Tenasserim river; and, although no cassiterite was found here in the pegmatite, it was obtained in the superincumbent soil. Tin-bearing *kra* was also found south of Yaungwa on the new road to Karathuri, and in the Kyoukchychaung to the south of a large isolated hill of granite.

(2) *In massive quartz-segregations in and on the outskirts of granitic hills.* Some of these segregations are several feet in thickness, and sometimes carry also wolfram, pyrite and chalcopyrite. Examples: North Hill, Khow Maung (Centre Hill) and Peetoolai in the neighbourhood of Maliwun.

(3) *In quartz-veins and stringers in ground adjacent to decomposing pegmatite.* In cases like that at Youngwa it is necessary to remove the matrix with the small stringers for the separation of the cassiterite.

(4) *Hill-side talus accumulations due to the disintegration of classes* (1), (2) *and* (3), extending to gravel deposits along the

[1] *Records, Geol. Surv. Ind.*, XXVI, p. 153, 1893.

stream valleys and in alluvial flats. These form the deposits most generally worked by the Chinese and Siamese immigrants.

56. The following tin-mining localities were examined by Mr. Page :—

(1) *Maliwun area :* (*a*) Klong Bankwa (10° 14′; 98° 38′). Several small workings by Chinese. The only working apparently profitable yields 6 lbs. cassiterite per cubic yard of "dirt".

(*b*) Klong Nam Sai (10°16′; 98° 39′). Only one working, carried to a depth of 42 feet, where rich tin-bearing material is found, but the mine is hampered by the cost of dealing with a great overburden.

(*c*) North Hill, Peetolai and Centre Hill, taken up by the Burma Development Company under mining lease. In this area stanniferous quartz segregations are being exploited.

(*d*) Hassei Deng (10° 9′; 98° 37′) and (*e*) Klong Glama (10° 12′; 98° 39′). Old abandoned workings only.

(2) *Karanthuri area :* (*a*) Chaungtenaung (10° 53′; 98° 46′). Two workings in alluvium, yielding also small quantities of gold. (*b*) Chaungkapra (10° 55′; 98° 48′). Five workings in alluvium. (*c*) Karathuri (10° 56′; 98° 48′) 22 workings on the hill-sides and low ground.

(3) *Yaungwa to Bôkpyin :* (*a*) To Twe (11° 4′; 98° 46′). Two workings. Tin occurs also in the mangrove swamps below high-tide level. (*b*) Hangpru (11° 1′; 98° 50′). Three active workings, and others abandoned. (*c*) Yaungwa (11° 8′; 98° 52′) to Inner Bôkpyin (11° 14′; 98° 50′). Four native mining leases owned by Messrs. Kinloch and Eglington are being worked; fifteen native workings besides prospecting licenses granted to two European companies who have closed operations.

(4) *Bôkpyin to Yengan :* (*a*) Sadien (11° 23′; 98° 48′). Many abandoned old workings. (*b*) Migyaung chaung (11° 25′; 98° 47′). Workings in pegmatite and alluvium; the deposits are rich, but difficult to work on account of want of water. (*c*) Yengan (11° 27′; 98° 48′). Seven workings in good alluvium, hampered by want of water. The alluvial flats would be worth testing by borings with a view of pond-dredging from the adjoining creek.

(5) *Manoron area :* Keh chaung and Hesamkong (11° 31′; 99° 12′). Eighteen apparently profitable workings operated only in the rainy season. Stanniferous quartz stringers in one working only, the remainder being alluvial.

(6) *Mergui area:* Yamon (12° 13′; 98° 47′) to Naukle (12° 18′; 98° 47′). Eight workings, all shallow, yielding cassiterite from ½ to 2 lbs. per cubic yard of the stanniferous layer, which varies from 18″ to 3 feet in thickness. The locality is possibly worth prospecting with a view of dredging.

(7) *Great Tenasserim Valley:* (*a*) Tagu (12° 16′; 99° 4′). One lease being worked besides abandoned old workings. Wolfram in white quartz fragments found with the alluvial tin, but not found *in situ.* (*b*) Theindaw (Tendau) (12° 20′; 99° 10′). Many old workings showing "pay-dirt" at a depth of about 16 feet. Concessions have been granted for working on European lines.

(8) Thabalik (12° 1′; 99° 15′) near the Siamese boundary. Five native leases being worked. The "pay-dirt" appears to be richer than in most places. In the streams wolfram was found in quartz fragments.

## Tungsten.

57. While prospecting for manganese-ore in the Nagpur district Mr. J. Kellerschon, Agent in India for the Carnegie Steel Company, came upon a vein of mineral that proved to be wolfram on determination by Mr. G. G. Narke, a student-apprentice on the Geological Survey. Mr. Fermor was accordingly requested to examine the occurrence during the course of his annual inspection of the manganese-mines in December, 1907. Meanwhile, the occurrence was developed by Mr. Kellerschon, to whom we are indebted for more material and full facilities for studying the deposits. According to Mr. Fermor's description, the deposit as exposed lies within the boundaries of Agargaon in the Umrer tahsil, where the wolfram is found as a constituent of quartz-veins intercalated in mica-schists and tourmaline-schists that belong to the Dharwar system. The wolfram bearing veins are more intimately connected with the tourmaline-schists, and the formation of the tourmaline was probably due to the same mineralising agencies which gave rise to the deposition of the wolfram and quartz in fissures opened along the foliation-planes of the schists.

The wolfram is irregular in its degree of concentration, and work had not proceeded far enough at the time of Mr. Fermor's visit to settle with certainty the economic prospects of the deposit.

Crystals of the wolfram generally vary from ½ to 2 inches in diameter, but some of them measure as much as 4 to 5 inches across. The quartz-wolfram veins are of all sizes, from thin "stringers" to about 18 inches thick, and they permeate a band of "country" that may be 70 feet wide. The schists and included veins strike about W.S.W.—E.N.E., and prospecting licenses have been granted for the extensions in both directions from the original locality in Agargaon. Nothing was found at the surface to indicate this occurrence and the chance discovery in a prospecting pit put down because of some black stains supposed to be manganese-ore, gives an idea of how much is hidden in Peninsular India under the monotonous peneplain, in which the rocks are masked by a thin envelope of soil.

## Water.

**Ajmer.**

58. Owing to the considerable growth of the city of Ajmer, whose prosperity within recent years has been greatly increased by the presence of the Railway workshops, the question of increasing the water-supply has become imperative, as, owing to the increase in the demand, the amount of water supplied by the present scheme threatens to fall short in years of drought. Owing to the elevated situation of the city, there is no hope of being able to furnish the supply by gravitation alone, and Mr. Vredenburg, who was deputed in April 1907, to report on this question, deprecates any scheme relying solely upon artificial or natural lakes, where the evaporation is great and the supply depends largely upon a rather precarious rainfall. The streams are all liable to dry up entirely during part of the year, and Mr. Vredenburg is of opinion that a sufficient supply should be obtainable by sinking large percolation wells through the thick alluvial formation that occupies the neighbouring valley. The fact that wells of this sort suffice to irrigate an area of several square miles in the neighbourhood of the town, even during years of greatest scarcity, is an indication that the supply must be ample for the needs of the city. For the practical utility of any scheme it is important that the sources of supply be not too much scattered. Experiments are therefore being conducted in the hope of finding some convenient spot from which the whole supply or a considerable fraction of it might be obtained.

Mr. Vredenburg examined a number of wells within a radius of about 12 miles from the city, and came to the conclusion that the valley of the Sagarmati, south of the town, and that of the Sarsuti, west of it, appear the most promising areas, the first-named benefiting by a large drainage area. The wells are now being systematically tested, and experimental borings are also being sunk through the alluvium.

From one of these borings, put down in the month of June by Mr. Goodwin, in the Sarsuti valley, the water rose above the surface, and has continued flowing ever since, indicating the existence of artesian conditions, and thus reproducing on a small scale those observed in Baluchistan. There is a gentle slope of the alluvial formation from the hill-range bordering the Sarsuti valley on its eastern side, down to the river bed; the alluvial formation includes alternating layers of clay and of sand, the latter being blown sand re-distributed by rain, and it is this alternation of pervious and impermeable strata, combined with the slope of the ground, which accounts for the artesian conditions observed.

The hill ranges and the rocks underlying the alluvium belong to the Aravalli system of ancient schists, which are impervious, or in which water occurs only in fissures that cannot be systematically explored.

## GEOLOGICAL SURVEYS.

### Central India.

**Area surveyed.**

59. Although it was necessary to retain Mr. Middlemiss at head-quarters to complete his report on the Kangra Earthquake, he remained in charge of the Central India party, which consisted of Messrs. H. Walker, A. M. Heron and Sethu Rama Rau. The officers in the field continued the survey in a general westerly direction from the area done last year, with the result that the following Standard Sheets on the 1" = 1 mile scale have now been added to the completed list:—Nos. 212, 276, 277, 306 and 334; whilst portions of the following have been mapped:—Nos. 211, 213, 242, 243, 244, 274, 275, 303, 304 and 335. Of these the western area, included in Nos. 211, 212, 213, 242, 243 and 244, was surveyed by Messrs. Walker and Heron, and the eastern area, included in Nos. 274,

275. 276, 277, 303, 304, 306 and 334, by Sethu Rama Rau. The latter also entered sheet 335, and revised portions of it with special reference to the iron-ores of the Sendrani neighbourhood.

**Connection with previous surveys.**

Omitting areas belonging to the Gwalior State, the Central India survey has now linked up with the previous survey of the Lower Narbada valley by Mr. Bose (*Mem. Geol. Surv. Ind.*, Vol. XXI, Pt. 1, 1884) and with that of the Dhar State by Mr. Vredenburg, all of which region lies to the south and south-west of the area just completed. During the present field-season it is hoped similarly to link up (with possible revision) with the areas mapped by Messrs. Hacket and Kishen Singh, which lie to the west and north-west of the area now in progress.

**Western Area.**

60. The western area surveyed by Messrs. Walker and Heron lies within lat. 22° 30″—23° 30′ and long. 74° 30′—75° 20′. This area included the whole of the Pitlawad pargana of the Indore State, the greater portion of the Jhábua State and parts of Rutlam State.

**Disposition of Rock Formations.**

61. Rocks of the Arávalli series occupy the south-western corner and a portion of the western side of this area, which lies entirely in Jhábua territory. Along the southern and a part of the eastern margin of this Arávalli outcrop, platforms of Lameta beds lie horizontally and unconformably on the schists and granites. The remainder of the country surveyed is occupied entirely by Deccan Traps.

**The Arávalli Series.**

62. The position of this outcrop of Arávalli rocks as an inset in the margin of the Deccan Trap—leads one to infer that they have at one time being covered by Deccan Trap. This view is strengthened by the fact that several rivers which flow from the basalts on to the Arávallis have cut back the former and exposed tongues of the latter. The sameness in the general maximum level of the Arávalli rocks is what one would expect as a result of the removal of the basalts. Streams have cut up the surface into low, round-backed hills. The chief rock types represented are—

Sericitoid-phyllites, quartzites, quartz-schists, granites and limestones. Locally gneisses are met with. Mr. Walker notes that many of the granites contain large quantities of pale-brown sphene. In the west (Walker), and also in the east (Heron), the occurrence of an amphibole-quartz-rock in conjunction with granite masses

has been described. Further it has been found that in one place in the west the above rock passes into an amphibolite. Actinolite also is an occasional constituent in this series (Walker). A more definite relationship of amphibole rock to granite could not be determined owing to the occurrences being much obscured by soil. The limestones are interesting; for Mr. Heron reports one containing green epidote, and another, found in the west, has such an amount of sericitoid material as to warrant it being named a calc-schist. Throughout the Arávalli series the predominant characteristic is the exceeding acidity of the rocks. The phyllites have well developed white quartz lenticles and veins, and even the limestones are thickly traversed by veins of quartz. Muscovite is the chief mica in the granites; biotite is not common. To the north of the outcrop and along its eastern face the general strike is E 20°—30° S. This changes to S 20° E. in the south and west. The rocks are much folded, often steeply, and the dips are high, irregular, and often vertical. The phyllites still preserve traces of bedding, and the granites also retain to a large extent their original structure.

**The Lameta Series.**

63. As in the case of the Arávalli series, the Lameta rocks are exposed only in Jhábua State. The peculiar distribution of these rocks is worthy of note. One small isolated patch of Lameta rocks was found lying horizontally and unconformably on the Arávallis at the northern end of the exposure. They occur fringing the margins of the Deccan Trap outliers in the neighbourhood of Jhábua City, but do not underlie the margin of the main basalt flow in this area. A few miles to the south the Lametas crop out between the Arávalli rocks and the basalts. From this point they crop out almost without break; and to the south of the Arávalli exposures they form platforms of large extent. Not only is the distribution peculiar, but so is the change in lithological character. The northern exposures are of the type previously referred to as Lameta; being described as generally calcareous, pale in colour, containing much sandy admixture, occasionally cherty, and with an uppermost layer characterised by well-rounded pebbles of quartz, quartzite, and bright red jasper (*Rec. Geol. Surv. Ind.*, XXXV, General Report for 1906, p. 55).

As one follows the outcrop to the south, one finds a great increase in the conglomerate beds. Grits occur very frequently, and locally the rocks are entirely silicified and very cherty. In places

fossiliferous, siliceous limestones were found and a few patches of true fossil-limestone were discovered. Among the fossils found were specimens of *Rhynchonella*, *Terebratula*, *Ostrea*, several genera of *Lamellibranchiata Gastropoda* and *Bryzoa* (Walker). Thus, in this area a change similar to that described by Mr. Vredenburg in the Dhar Forest[1]—from beds of estuarine type (Lameta) to those of marine type (Bágh) has been seen.

Mr. Heron notes that near Dhandalpura a bed of coarse grit occurs which is burnt by the basalt capping it. This bed is in small gentle folds. Mr. Walker also remarks on an outcrop of Lameta limestone to the south of Piplade where dips of 4° were measured. Cases in which the Bágh beds have been eroded[2] previous to the outflow of the basalts, and in which the basalts rest immediately on the Arávallis and at a lower level than the surrounding Bágh beds, have been described (Walker). The base of the series has not been seen, but the maximum thickness developed in this area appears to be not more than 30 feet.

**Deccan Trap.**

64. Although the major portion of the area surveyed during the field season is occupied by Deccan Trap, very little new information concerning these enormous masses has been obtained. Three beds of what appears to be fragmental volcanic ejecta were found intercalated with the normal basalts of the Deccan Trap. The uppermost one is near the top of Kukinda hill (Jhábua State) at a height of 1,450 feet (Walker). The other two occur to the N.E. in the Pitlawad pargana of the Indore State. The upper one of these is at a height of 1,300 feet, is about 3 feet thick and is the middle member of the basalt series forming the small hills surrounding Bamnia Railway Station. The lower is to be met with in the bed of the Larki river at Pitlawad town and in neighbouring streams. The bed, which is between 4 and 5 feet thick, consists of small angular blocks of the normal vesicular and amygdaloidal basalt of the district, in a matrix of finer materials; the whole is much decomposed, contains numerous cavities lined with calcite and various zeolites, and is in many places stained red and green. These two beds have been found at intervals over an area of about 130 square miles, the approximate centre of which is Pitlawad Town.[3]

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1 General Report for 1902-3, p. 20.

2 Geology of India, 2nd Ed., p. 275.

3 Mr. Middlemiss thinks the agglomeratic character of these beds may have been acquired by movement in a partially and irregularly consolidated flow of trap.

A small lenticular sill of quartz-felsite was found near Banri (Walker). An interesting dyke was found at Patbarli. The dyke-rock is an augite-plagioclose rock and shows ophitic structure (Heron). Olivine has not been met with during the course of the season's work.

**Alluvium and Soil.**

65. Except on the Malwa plateau the rivers and streams run for the most part in rocky beds with local banks of drift, pebbles, and pebbly conglomerates. In places along the Mahi river shelves of alluvium 20 feet in thickness are to be found. On the Malwa plateau the streams run most frequently between banks of cotton soil and kankar-gravel. The soil on the Arávallis and Lametas is thin and poor and exceedingly quartzitic. The phyllites give thicker and more argillaceous soil, but this is usually impoverished by the admixture of large quantities of quartz. On the slopes of the ghâts the soil is red and scanty, and thickly littered with trap fragments. In the flatter valleys and on the Malwa plateau there is usually a fair thickness of grey and black cotton soil. To the north and east of Rutlam town the soil is very thick and there are few rock exposures. However, water can be obtained from wells at depths between 30 and 40 feet, even at the end of the dry season (Heron).

**Economic Geology.**

66. The examination of the previously named portions of the Indore and Rutlam States has shown that there are no deposits of minerals of economic value; and concerning Jhábua State it has been found that the Arávalli series includes the only rocks that carry mineral deposits.

**Manganese-ore.**

67. The undermentioned known deposits were visited :—At Amlamál the manganese-ore occurs as psilomelane in a fine-grained spessartite-quartz-rock. The lode is thin and is ill-defined and the ore is mixed with quartz. The manganese-ore at Tumdia is found in veins and lenticles of white quartz, the surrounding rocks being sericitoid phyllites. The ore-bearing band is between 2 and 3 feet in thickness and about 200 yards long. In parts the ore is good, but on the whole is too quartzitic.

At Pipal Kotha, which lies midway between the manganese mines of Kájlidongri and Rambhapur, there are two outcrops, in line, of a pale-lavender coloured quartzite carrying an ore band of psilomelane mixed with pyrolusite. The outcrop is never more

than one yard wide and the total length exposed is about 100 yards. The ore is of good quality, but there is too large a percentage of quartz for the deposit to be of economic value. Two deposits of manganese-ore and one of an iron-manganese-ore were found in the Pitol district. All of these are small and poor in quality. Traces of manganese-ore were found in five other places. These were usually pyrolusite in the white quartz veins of the phyllite series.

**Mica.**

68. Reported deposits of mica occurring near Kanás and Ránápur were found to be derived from medium-grained pegmatite veins. They are of no value.

**Iron-ore.**

69. The ironstone deposit at Piplade, and also that in the Sánár river between Parwet and Gadwara, are too small and of too low a quality to admit of successful working.

70. A supposed China-clay from Ránápur is a fine-grained, white, siliceous limestone.

**Eastern area.**

71. The eastern area surveyed by Sub-Assistant M. M. Ry. Sethu Rama Rau lies entirely within lat. 22° 30′—23° 30′ and long. 75° 30′—76° 30′, and is contained in the Mehidpur, Indore and Nimawar districts of the state of Indore. It embraces irregular areas of the Malwa plateau of Deccan Trap stretching north and north-east of Mhow, and a narrower area to the east of Mhow, where the Malwa plateau descends in a southerly direction by three fairly well-marked terraces or scarps to the lowlands of the Narbada valley. The range of altitude is between 2,100 and 950 feet. It is only in the area to the east of Mhow that formations older than the Deccan Trap emerge from beneath the latter in the wide valley of the Narbada.

**Older formations: Archæan, Bijawar and Vindhyan.**

72. The older formations form part of the same complex which further west has been recently mapped in detail by Messrs. Vredenburg and Fermor (see General Report, Geol. Surv. of India for 1902-1903, p. 20), following on the older survey of Blanford (*Mem. Geol. Surv. Ind.*, Vol. VI, Pt. 3, 1869) and Bose (*Mem. G. S. I.*, Vol. XXI, Pt. 1). Of these the Archæans are represented by granitic and mottled hornblendic gneiss, and hornblende-chlorite schists, exposed to the east of Satwas and occupying the low country between the base of the Deccan Trap and the Narbada river as

far as the limits of sheets 334 and 335 go in that direction; the foliation strike being N. 10° W.—S. 10° E. near Kathargaon and Bagda, but near the Narbada being nearly E.—W. The Archæans are traversed by many doleritic dykes which near Kathargaon generally keep a direction N. W.—S. E. They are crystalline and fine-grained, and with semi-glassy selvages, and appear to be different to the basalts, etc., of the Deccan Trap. Quartz veins also traverse the gneiss, in some of which, such as those at Tamkhan,[1] copper pyrites with malachite alteration products are present, and also iron pyrites. The Tamkhan veins run N.—S. and are 4-5 feet thick and about ½ mile long. They are situated on the Narbada (lat. 22° 28′ long. 76° 52′) and were quarried and smelted about 150—200 years ago by the ruling chiefs. The pits are now filled-in with fallen material and it was impossible to learn whether the whole of the ore-body had been worked out or not, but the sides of the vein seem to have been richer in pyrites than the middle. Other veins between Kharia and Jinwani (lat. 22° 19′, long. 76° 45′) also run nearly N.—S. and show tourmaline and a few copper stains, but pyrites is not seen *in situ*. The exposures were however very jungle-covered. No gold was found in these quartz veins.

**Copper-ore.**

73. The Bijawars in sheets 334 and 335 occur firstly as inliers in the form of small hills rising from among the basal bed of the Deccan Trap, as seen in the neighbourhood of Sukras (22° 40′, 76° 52′), and secondly further south forming an L-shaped outcrop among the Archæans between Sendrani (22° 28′; 76° 40′) and Piplia on the Narbada. The lower division, consisting of coarse and fine conglomeratic quartzites, is exposed in the Sukras area, and the upper division of brecciated jaspideous quartzite and cherty limestones in the Sendrani-Piplia area. The upper division is said to lie unconformably upon the Archæans, but the brecciated bands, always found at the junction with the granitic gneisses in the southern area, might be understood to indicate an intrusive action of the Archæans. The problem here appears to be a repetition of what is found in other parts of India where similar rocks occur; and the apparent irrationalities of the dip indications are also not in favour of a simple superposition theory for the Bijawars.

**Bijawars.**

[1] Referred to by P. N. Bose, *loc. cit.*, p. 69.

**Vindhyans.**

74. A system of sandstones, shales and conglomerates occurring as inliers among the basal bed of the Deccan Trap, and also as a large connected outcrop to the west of Satwas, probably belong to the Vindhyan system, and perhaps to the Lower Vindhyans. They are inclined at moderate angles, generally towards the south-west. Their exact horizon is not yet clear. Bose has marked them as Upper Vindhyan, whilst Vredenburg has marked their western extension as lower Vindhyan.

**Deccan Trap, etc.**

75. As seen in sheet 324, the Deccan Trap begins with a lowermost bed which occupies the flat plains for several miles before the upper beds which compose the scarp appear. This lower bed makes no special orographical feature with the older rocks of the Vindhyans, Bijawars and Archæans, above which it is described as lying unconformably, and without the intervention of any Lametas, such as occur in other neighbouring areas to the west. Above this the scarped edge of the Malwa plateau rises more than 1,000 feet in beds of softer and harder Deccan Trap, some of which are columnar, and some containing the usual geodes full of siliceous or zeolitic material. Deccan Trap occupies the rest of the country surveyed, with the exception of a very few cappings of laterite, some further exposures of the sub-recent calcareous concrete noticed in the last General Report (*Rec. Geol. Surv. Ind.*, XXXV, 57), together with alluvial stretches in the valley systems, cotton soil and calcareous tufa.

**Sendrani Iron Ores.**

76. The Sendrani (22° 28′; 76° 40′) iron ores were specially investigated, and the positions of the old mines recorded on the map by Sethu Rama Rau. The ores were found to be exposed in ancient pits at several places scattered over the Bijawar area to the south and south-east of Satwas, and also along the junction between the Bijawars and the Vindhyans. The original rock appears to have been a hæmatitic shale at the base of the latter, but the ore also occurs lining hollows and fissures in the underlying Bijawar breccia, from which it has again been accumulated in the form of nodules and lumps scattered about in the disintegrated surface rock. In competition with imported iron the industry has gradually died out in later years.

## Central Provinces.

77. During the field season Mr. P. N. Datta completed a survey of the previously unmapped areas in the Bhandara district. The

only features of geological interest deserving special mention are the large outcrops of post Vindhyan diabase, possibly connected with the Deccan Trap eruptions, and the sections which clearly show the great unconformity between the Vindhyan sandstones and the vertical beds of Dharwar schists below. No fossils were obtained from the Gondwana rocks exposed in Bhandara and adjoining parts of Chanda, and no new occurrences of valuable minerals were recorded.

## Burma.

78. Surveys carried out in the oilfields of Minbu, Magwe, Myingyan and Pakokku districts are referred to under *Petroleum*, while the exploratory work done in Mergui is reviewed under *Tin-ore.*

**Northern Shan States.**

79. The survey of the Northern Shan States was continued by Messrs. T. D. LaTouche and J. Coggin Brown during the field-season of 1906-07 in two separate areas, (i) that comprised in Sheets 331 and 332 of the one-inch Topographical Survey, lying along the valley of the Nam-Tu above Hsipaw, and including the tract north of Sheet 331 in which the silver-lead mines of Bawdwin are situated, which has not yet been surveyed on the one-inch scale; and (ii) the hill ranges between the Shan plateau and the Salween, extending southwards from the Loi-len range E. of Lashio to the plains of Kehsi Mansam in the Southern Shan States, comprised in Sheets 433, 434, 435, and 436 of the one-inch survey. The whole area mapped was about 3,300 square miles.

80. The geology of the Nam-Tu valley had previously been studied by Messrs. Datta and Pilgrim, and to some extent by Mr. LaTouche, but Mr. Datta had confined his attention mainly to the upper Palæozoic and Mesozoic rocks, and the discovery of hitherto unrecorded beds containing characteristic fossils has necessitated several changes in the mapping of the boundaries laid down by Mr. Pilgrim. The most interesting of these discoveries was that of a band containing graptolites, of the same type as those which had been found during the previous season in the Kehsi Mansam district, at the base of the Namhsim sandstones at Panghsapyé, a village about 8 miles north-west of Hsipaw. These graptolites are of quite a different type from those of the Zebingyi beds, described by Mr. Cowper Reed in the *Palæontolgia Indica*, and belong to an older horizon, probably of Llandovery age. The beds in which they are found immediately overlie a band of purple shales, which was formerly considered as the base of the Silurian Namhsim sandstones, but the discovery of this graptolite zone shows that

the purple band must belong to the much greater thickness of purple and grey shales found last year on the eastern flanks of the Loi Twang range in Kehsi Mansam, from which Ordovician trilobites were obtained. The purple band of Panghsapyé and the neighbourhood must therefore be considered as the uppermost member of the Naungkangyi group of beds. There is no apparent unconformity in the Nam-Tu valley between the Naungkangyi beds, Purple band, Graptolite band, and Namhsim sandstones, and if the graptolites (which have not yet been examined by a trained palæontologist) should turn out to be Llandovery forms, we should have here a complete succession from Lower Ordovician to Silurian strata.

81. The Graptolite and Purple bands were traced northwards from Panghsapyé across Sheet 331 and were of great assistance in mapping the boundaries of the formations. The Purple band also extends from Panghsapyé to the south-west as far as the head of the Gokteik Gorge, but the Graptolite band above it appears to be absent in this direction, or at any rate has not yet been detected. It is for this reason that the connection of the Purple band with the Naungkangyi beds below was not previously recognised.

82. Along the gorge of the Nam-Tu above Hsipaw the succession of the rocks is normal, the Naungkangyi beds occurring along the slopes of the valley on the west side and in the bed of the river, followed at the base of the precipitous scarp on the east side by the Purple and Graptolite bands. These are succeeded by the Namhsim sandstones, which form the whole of the scarp overhanging the river, and are capped by the Plateau limestone, which forms a strip of undulating, high ground, parallel to the gorge, and in its turn disappears to the east beneath the red sandstones of the Namyau series, the dips throughout being easterly. But to the west of the river the Naungkangyi beds, instead of being followed by the older unfossiliferous rocks of the Chaung-Magyi series, are found overlying, with apparent conformity, a series of sandstones in which Namhsim fossils, among others *Orthonota* and *Encrinurus*, have been found. The boundary line is almost straight, running nearly due north and south, and it is evident that the Naungkangyis have been pushed up along the line of a fault above the sandstones. Within a few miles to the west the dip of the sandstones becomes less, and their lower beds are found resting quite unconformably upon the upturned edges of the Chaung-Magyi rocks, entirely overlapping the Naungkangyis.

83. The great fault mentioned above has been traced northwards into the Bawdwin area, where it inclines somewhat to the

west of north and, leaving the fossiliferous Palæozoic rocks, traverses the rhyolitic tuffs and rhyolites of Bawdwin, which form the uppermost member of the Chaung-Magyi series. To the intense crushing and disturbance caused by this great dislocation is probably due the opportunity for the mineralization of the Bawdwin rocks. A separate report on this subject will be published in the *Records*.

84. The geology of the hill-ranges east of the plateau, though in general sequence similar to that of the western portion of the Shan plateau, exhibits several important differences in detail. The low ground separating the various ranges is invariably occupied by the Plateau limestone, with an occasional outlier of the red Namyau sandstone, or of the Tertiary coal-measures, resting upon it. The limestone tracts invariably present the same aspect of undulating, thinly-wooded plateau, generally at a lower elevation than the older rocks forming the core of the ranges, but sometimes rising on their flanks into precipitous scarps facing the axis of the range, or in some cases arching completely over them, thus proving that the limestones participated in the orogenic movements resulting in the elevation of the ranges. The structure of these is similar in all cases, consisting of an elongated dome, more or less modified by subsequent faulting. In the centre of each dome is a core of ancient rocks, belonging to the Chaung-Magyi series, and generally forming the highest elevations. The great mass of Loi Ling, the highest peak in the N. Shan States, rising to 8,771 feet above the sea, is entirely formed of these rocks. Along the flanks of the core is found a zone occupied by the Lower Palæozoic fossiliferous rocks, but the facies of these in not quite the same as in the western sections. The Naungkangyis are reduced to a band of calcareous sandstones of no great thickness (with *Rafinesquina* and other characteristic fossils belonging to that group), whereas the thickness of the overlying purple shales is enormously increased. These latter beds in this area probably include a portion of the Naungkangyi group of the western sections, since they contain *Pliomera insangensis* Reed, one of the characteristic trilobites of the Upper Naungkangyis, but the fossils from the purple beds have not yet been determined. They include many large trilobites belonging to the *Asaphidæ*, as well as *Ampyx*, *Bronteus*, etc.

85. The Graptolite band of Panghsapyé has been found in several localities overlying the purple shales, and has helped considerably in unravelling the complicated structure of these ranges. The great development of sandstones (Namhsim sandstone) which succeeds it on the Nam-tu appears to be absent, but some marly

beds, which are found at the top of the sandstones in the west, are found in places immediately below the Plateau limestone, and appear to be the only representatives of the Silurians in this area.

86. At the top of the Chaung-Magyi series, and immediately underlying the Naungkangyi beds, a series of volcanic ash beds, with thin flows of rhyolite, were found in several localities among these ranges. These correspond closely, both in position and petrological characters, with the tuffs and rhyolites of Bawdwin. In some places a conglomerate of well-rolled pebbles occurs at their base, apparently shore deposits, accumulated in the interval between the consolidation of the Chaung-Magyi rocks and the beginning of the Naungkangyi epoch. The blocks of quartz-porphyry, noted by Dr. Noetling in the bed of the Namma river, in his account of the coalfields of the N. Shan States (*Rec. Geol. Surv. Ind.*, Vol. XXIV, Pt. 2, p. 110) are derived from these beds, which occur at the crest of the range east of Lashio, on the north side of the Nampawng, a tributary of the Namma.

87. As the survey of this area may be interrupted by urgent requests elsewhere, it may be desirable to summarise the chief stratigraphical results obtained by Mr. LaTouche and his colleagues. The geological reconnaissance has now been carried over 24 sheets of the one-inch map covering an area of 13,000 square miles, though much still remains to be done in working out the details of the geological structure of the plateau and its surroundings.

The formations that have been identified by means of their fossils, with their European equivalents, are the following:—

| Local names. | European equivalents. |
|---|---|
| Late Tertiary freshwater silts with coal, Lashio, Namma, etc. . . . . . . . . | Late Pliocene or Pleistocene. |
| Namyau beds,—Red sandstones with bands of limestone near base . . . . . | Jurassic (exact horizon not yet known). |
| Napeng Shales . . . . . . . . | Rhætic. |
| Fusulina and Productus Limestone . . . | Permo-Carboniferous. |
| Plateau Limestone . . . . . . | Carboniferous and Devonian. |
| Zebingyi graptolite beds . . . . . . | Silurian. |
| Konghsa Marls . . . . . . . | Silurian. |
| Namhsim Sandstones . . . . . . | Silurian. |
| Panghsapyé graptolite band . . . . . | Ordovician. |
| Hwe Mawng Purple Shales . . . . . | Ordovician. |
| Naungkangyi beds . . . . . . . | Ordovician. |
| Chaung Magyi series . . . . . . | ? Cambrian. |
| Archæan schists and gneisses. | |

88. The Chaung-Magyi series is composed of slaty shales and quartzites, which may be of Cambrian age, but in which no fossils have as yet been found; these rocks rest upon the Archæan mica-schists and gneisses of the Ruby-Mines District.

89. In Ordovician and subsequent times the older rocks, the Archæan gneisses and mica-schists, with the Chaung-Magyi series, formed a tract of land, extending along the north-western border of the position now occupied by the Shan plateau, with perhaps a few islands, composed of similar rocks, to the south-east of the old coast line. Along the borders of these land areas the Ordovician and Silurian rocks were deposited, followed by a great accumulation of reef deposits, now represented by the limestones covering the greater portion of the plateau, and extending to the south at least as far as Tenasserim. This period closed with the deposition of limestones containing *Fusulina* and *Productus*, probably contemporaneous with the Middle Productus Group of the Salt Range.

90. The succeeding formation, the Napeng Shales, has been found to contain a peculiar fauna, consisting almost exclusively of Lamellibranchs, of Rhætic age. These shales apparently filled up hollows in the Plateau limestone, either due to original inequalities in its surface, or to irregular solution of the limestone during the period that had elapsed since its deposition. Another break then occurs, during which denudation of the limestone took place, indicated by the presence of conglomerates, with pebbles derived from it, at the base of the succeeding formation. This latter, the Namyau series, consists of red sandstones, interstratified in their lower portion with bands of limestones containing Jurassic fossils. Hitherto no fossils have been found in the upper portion of this series, and it is uncertain whether any part of the Cretaceous period is represented.

91. After the accumulation of the Namyau beds marine deposition ceased entirely over the whole area, none of the lower or middle Tertiary formations being present. In all probability the great earth-movements at the opening of the Tertiary period converted the whole of Burma east of the Irrawadi and Sittang valleys into dry land, subject to aerial denudation, and the Late Tertiary silts with coal, occupying a series of basins surrounding Loi Ling, the highest ground in the States, were evidently deposited after the main drainage features of the plateau had been marked out. Indeed, these beds of silt may be of Pleistocene, or even sub-recent age.

92. It is somewhat surprising that igneous rocks are of extremely rare occurrence over the whole of this area. The ancient rocks near Mogok (Ruby-Mines) are traversed by great bands of granite, and there are indications of volcanic conditions, consisting of rhyolites and rhyolitic tuffs, along the borders of the Ordovician land surface; but throughout the whole sequence of Palæozoic and Mesozoic strata there are no traces whatever of volcanic activity. In Late Tertiary times there was, however, a feeble manifestation of these agencies, for in one locality the silts were found to be traversed by dykes of basalt, resembling that of the sub-recent volcano of Hawshuenshan, near Tengyueh (Momien), in south-west Yunnan.

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# THE MINERAL PRODUCTION OF INDIA DURING 1907. BY SIR T. H. HOLLAND, K.C.I.E., D.Sc., F.R.S., *Director, Geological Survey of India.*

## CONTENTS.

# I.—INTRODUCTION.

THE present summary of returns for mineral production in India during 1907 covers the fourth year of the quinquennial period current since the issue of the Review of Mineral Production for 1898 to 1903 (*Records*, Vol. XXXII, Pt. 2).

A detailed statement of production and statistics regarding labour at the mines regulated by the Indian Mines Act has been published with the Annual Report of the Chief Inspector of Mines. It should be remembered that in this, as in other, Annual Reports, the Chief Inspector of Mines gives data for output and labour only for mines under the Act, and does not include statistics regarding the production of mines in Native States, or of various minor products raised from superficial workings to which the Act has not yet been applied. In the present statement, however, the totals refer to the whole of India, including the protected States, and, so far as returns are obtainable, include the minor products reported by Local Governments and Political Agents.

No change has been made in the grouping of the minerals adopted in previous statements. They are divided as follows:—

*Group I*:—Minerals for which approximately full returns are obtainable, and

*Group II*:—Minerals for which returns are admittedly incomplete or only approximately estimated.

TABLE 1.—*Total Value of Minerals for which Returns of Production are available for the years 1904—1907.*

| MINERAL. | 1904 | 1905 | 1906 | 1907 |
|---|---|---|---|---|
| | £ | £ | £ | £ |
| Gold . . . . . . | 2,366,079 | 2,416,971 | 2,230,284 | 2,133,691 |
| Coal (*a*) . . . . . | 1,398,826 | 1,419,443 | 1,912,042 | 2,609,726 |
| Petroleum (*a*) . . . | 473,971 | 604,203 | 574,238 | 610,015 |
| Salt (*a*) . . . . . | 437,530 | 441,392 | 420,901 | 434,076 |
| Saltpetre (*b*) . . . | 266,349 | 235,723 | 270,547 | 274,679 |
| Manganese-ore (*b*) . . . | 129,632 | 248,309 | 435,268 | 589,830 |
| Mica (*b*) . . . . . | 83,183 | 142,008 | 259,544 | 226,382 |
| Carried over . | 5,155 570 | 5,508,049 | 6,102,824 | 6,878,399 |

(*a*) Spot prices.
(*b*) Export values.

| MINERAL. | 1904 | 1905 | 1906 | 1907 |
|---|---|---|---|---|
| | £ | £ | £ | £ |
| Brought forward | 5,155,570 | 5,508,049 | 6,102,824 | 6,878,399 |
| Ruby, Sapphire and Spinel | 90,612 | 88,340 | 96,867 | 98,258 |
| Jadestone (*b*) | 43,946 | 43,474 | 64,433 | 49,643 |
| Graphite | 16,726 | 16,890 | 10,009 | 7,387 |
| Iron-ore (*a*) | 11,442 | 13,828 | 11,344 | 13,381 |
| Tin-ore (*a*) | 8,353 | 9,917 | 13,799 | 11,882 |
| Chromite (*a*) | 4,137 | 3,482 | 7,188 | 9,699 |
| Diamonds | 2,636 | 2,474 | 5,160 | 2,784 |
| Magnesite (*a*) | 351 | 550 | 488 | 50 |
| Amber | 838 | 945 | 709 | 385 |
| TOTAL | 5,334,611 | 5,687,949 | 6,312,821 | 7,071,868 |

**Total value of Production.**

Although, during the past year, there has been again a fall in the value of gold produced, as well as in the case of the less valuable minerals, amber, diamonds, graphite, jadestone, magnesite, mica and tin-ore, there has been a very considerable, and more than compensating, rise in certain other cases. The total value for minerals of Group I produced in 1907 was £7,071,868, against the value of £6,312,821 in 1906, that is, an increase of £759,047 or 12 per cent. During the past four years of the current quinquennial period, the total value for minerals of Group I has consequently risen by 32·5 per cent.

**Principal Changes in value.**

For the first time the value of coal exceeds that of gold, and the former now takes the leading place in the list of Indian minerals. Although the total value reported for coal is fairly comparable to the figures returned for the previous years, the Chief Inspector of Mines, Mr. J. R. R. Wilson, has called my attention to the fact that, in the returns from many of the mines in Bengal, the values reported do not properly reflect the increased prices obtained during the year. On account of the existence of long-standing contracts, it is not to be expected that the high prices prevailing during 1907 would produce an immediate corresponding effect on the total values; but, according to Mr. Wilson, it is evident also that many of the Managers misunderstand the meaning of the expression

(*a*) Spot prices.
(*b*) Export values.

"pit-mouth value", and some of them have deducted the cost of raising coal from the prices obtained f.o.r., thus, in effect, returning as pit-mouth value only the profits obtained. Errors of this kind will be repaired, so far as possible, in future years.

It will be noticed that the value taken for manganese-ore has not risen in the same proportion as the production reported from the different provinces. Part of this is due to the fact that large stocks have been accumulated at some of the manganese mines; but, as stated before, the value adopted for manganese-ore is a purely artificial one, being assumed at the ports for cargoes not reported in actual value to be about £1 per ton. The values thus given for manganese-ore approximately reflect the increase in exports, but do not fairly gauge the value of the industry.

There has been a remarkable increase in the number of concessions granted for prospecting and mining, mainly due to increased interest in manganese in Bombay and the Central Provinces. The total number granted in 1906 was a considerable advance on those recorded for previous years; but in 1907 the concessions granted rose to 600. These figures refer only to concessions granted in lands in which the mineral rights have been reserved by Government, and do not include the large numbers granted in States and in areas where the mineral rights have been conceded permanently with the surface ownership. Practically all the coal-bearing land in Bengal comes under the latter category.

## II.—MINERALS OF GROUP I.

| | | | |
|---|---|---|---|
| Chromite. | Graphite. | Manganese-ore. | Salt. |
| Coal. | Iron-ore. | Mica. | Saltpetre. |
| Diamonds. | Jadeite. | Petroleum. | Tin. |
| Gold. | Magnesite. | Ruby, Sapphire and Spinel. | |

### Chromite.

There was again a marked increase in the production of chromite in Baluchistan, *viz.*, from 4,375 tons in 1906 to 7,274 tons, valued at £9,699, in 1907. Table 2 gives the figures of production and value since the commencement of the chrome-mining industry in 1903. The total production to the end of 1907 is 18,201 tons. Three new mines were opened for chromite-mining during 1907, making a total of 19 mines in operation, employing daily an average of 86 workers against 76 in the year 1906.

TABLE 2.—*Production of Chromite in Baluchistan since the commencement in 1903.*

| YEAR. | Quantity. | Value. | Value per ton. |
|---|---|---|---|
| | Tons. | £ | Shillings. |
| 1903 . . . . . . | 248 | 327 | 23·0 |
| 1904 . . . . . | 3,596 | 4,137 | 23·0 |
| 1905 . . . . . | 2,708 | 3,482 | 25·7 |
| 1906 . . . . . . | 4,375 | 7,188 | 32·9 |
| 1907 . . . . . . | 7,274 | 9,699 | 26·6 |

### Coal.

**Total production, value and average price.**

The returns for 1907 show that the activity in coal-mining has again greatly increased, the total production having reached 11,147,339 tons, against 9,783,250 tons in 1906, an increase of nearly 14 per cent. The average value of coal per ton at the mines has risen from Rs. 2-15-0 (3*s.* 11*d.*) to Rs. 3-8-0 (4*s.* 8*d.*)—an increase which is slightly below the rise in sale prices during the year (Table 3).

TABLE 3.—*Production and Value of Coal during the years 1904—1907.*

| YEAR. | Quantity. | Total Value at the Mines. | | Average. | Value per ton at the Mines. |
|---|---|---|---|---|---|
| | Statute Tons. | *Rupees* | £ | *Rs. a.* | *s. d.* |
| 1904 . . | 8,216,706 | *2,09,82,407* | 1,308,826 | *2 9* | 3 5 |
| 1905 . . | 8,417,739 | *2,12,91,649* | 1,419,443 | *2 8* | 3 4 |
| 1906 . . | 9,783,250 | *2,86,80,655* | 1,912,042 | *2 15* | 3 11 |
| 1907 . . | 11,147,339 | *3,91,45,900* | 2,609,726 | *3 8* | 4 8 |

**Provincial production.**

Table 4 shows the provincial production of coal for the past four years. It will be noticed that the total is dominated by the large and continuous expansion in the Bengal output, the other provinces showing unimportant variations.

TABLE 4.—*Provincial Production af Coal for the years 1904—1907.*

| PROVINCE. | 1904 | 1905 | 1906 | 1907 |
|---|---|---|---|---|
| | Statute Tons. | Statute Tons. | Statute Tons. | Statute Tons. |
| Baluchistan . . . . | 49,867 | 41,725 | 42,164 | 42,488 |
| Bengal . . . . . | 7,063,680 | 7,234,103 | 8,617,820 | 9,993,348 |
| Burma . . . . . | 1,105 | .. | 1,222 | .. |
| Central India . . . . | 185,774 | 157,701 | 170,292 | 178,588 |
| Central Provinces . . | 139,027 | 147,265 | 92,848 | 134,088 |
| Eastern Bengal and Assam | 266,765 | 277,065 | 285,490 | 295,795 |
| Hyderabad . . . . | 419,546 | 454,294 | 467,923 | 414,221 |
| Kashmir . . . . . | 270 | ... | .. | .. |
| Punjab . . . . . | 45,594 | 62,622 | 73,119 | 60,749 |
| Rajputana (Bikaner) . . | 45,078 | 42,964 | 32,372 | 28,062 |
| TOTAL . | 8,216,706 | 8,417,739 | 9,783,250 | 11,147,339 |

**Geological classification.**

Tables 5, 6 and 7 classify the production according to the geological formations worked. As the whole of the production in Bengal is from Gondwana strata, the coal of this age gradually makes a larger fraction of the total production, amounting in 1907 to 96·17 per

cent. of the whole output. The production of Gondwana coal in 1907 exceeded the total output of the whole of India for any previous year.

TABLE. 5— *Origin of Indian Coal raised during 1904—1907.*

| ——— | 1904 | 1905 | 1906 | 1907 |
|---|---|---|---|---|
| | Statute Tons. | Statute Tons. | Statute Tons. | Statute Tons. |
| From Gondwana coalfields . | 7,808,027 | 7,993,363 | 9,348,883 | 10,720,245 |
| From Tertiary coalfields . | 408,679 | 424,376 | 434,367 | 427,094 |
| **TOTAL, Statute Tons** | **8,216,706** | **8,417,739** | **9,783,250** | **11,147,339** |
| *Total, Metric Tons* . | *8,348,561* | *8,552,422* | *9,940,246* | *11,325,696* |

**Gondwana fields.**

Among the Gondwana fields, attention was drawn to the fact that, in 1906, the output of Jherria exceeded for the first time that for Raniganj, which was previously the leading coalfield. In 1907, this lead was increased, the Jherria field having produced nearly half the Gondwana coal raised in India. The only other point of special interest in connection with the Gondwana fields is the notable increase in the Central Provinces, due to rapid development of the iPench valley collieries. Systematic mining operations commenced n this field in 1905; the output jumped to 32,102 tons in 1906, and again increased to 74,663 tons in 1907. The Pench valley is at present served by a narrow-gauge railway only, but a broad-gauge connection between the Great Indian Peninsula Railway system at Itarsi and the combined Bengal Nagpur and Great Indian Peninsula Railways at Nagpur has now been sanctioned. The completion of this line will open up a larger market for the Pench valley coal; and, besides shortening the distance to the principal centres of consumption, the present disadvantage of a change in gauge will be avoided.

TABLE 6.—*Output of Gondwana Coalfields during 1904—1907.*

| COALFIELDS. | 1904 | | 1905 | | 1906 | | 1907 | |
|---|---|---|---|---|---|---|---|---|
| | Statute Tons. | Per cent. of Indian Total. | Statute Tons. | Per cent. of Indian Total. | Statute Tons. | Per cent. of Indian Total. | Statute Tons. | Per cent. of Indian Total. |
| *Bengal*— | | | | | | | | |
| Daltonganj | 50,517 | ·61 | 71,294 | ·85 | 86,768 | ·89 | 81,873 | ·73 |
| Giridih | 773,128 | 9·41 | 829,271 | 9·85 | 803,321 | 8·21 | 750,374 | 6·73 |
| Jherria | 2,889,504 | 35·17 | 3,070,588 | 36·48 | 4,076,591 | 41·67 | 5,179,185 | 46·47 |
| Rajmahal | 274 | .. | 414 | .. | 577 | .. | 257 | .. |
| Raniganj | 3,350,257 | 40·77 | 3,262,536 | 38·77 | 3,650,563 | 37·32 | 3,981,659 | 35·72 |
| *Central India*— | | | | | | | | |
| Umaria | 185,774 | 2·26 | 157,701 | 1·87 | 170,292 | 1·74 | 178,588 | 1·60 |
| *Central Provinces*— | | | | | | | | |
| Bellarpur | 90 | .. | 148 | ·02 | 916 | ·34 | 18,103 | ·16 |
| Pench Valley | .. | ... | 1,104 | | 32,102 | | 74,663 | ·67 |
| Mohpani | 26,618 | ·32 | 22,998 | ·27 | 27,503 | ·28 | 41,322 | ·37 |
| Warora | 112,319 | 1·37 | 123,015 | 1·46 | 32,327 | ·33 | .. | .. |
| *Hyderabad*— | | | | | | | | |
| Singareni | 419,546 | 5·11 | 454,294 | 5·38 | 467,924 | 4·78 | 414,221 | 3·72 |
| TOTAL | 7,808,027 | 95·02 | 7,993,363 | 94·95 | 9,348,884 | 95·56 | 10,720,245 | 96·17 |

With regard to the fields of Tertiary coal, the only areas calling for remark are—

**Tertiary coalfields.**

(1) Makum, where there has been a gradual increase in output, and

(2) Bikaner, where, during the past four years, there has been a decline. This decline, however, is due to the necessity of reorganising operations at Palana, the only colliery being worked in Rajputana. A large section of the mine having got on fire, has been walled off, and operations have been directed mainly towards this protective measure and the reorganisation of the system of galleries. It is anticipated that the work now in hand will be completed within the present year, and that a considerable increase in production will accordingly follow. The material raised at Palana is in reality a lignite containing a high percentage of moisture; it, however, is used on the Jodhpur-Bikaner Railway and for the production of electric power in Bikaner city.

TABLE 7.—*Production of Tertiary Coal in 1904—1907.*

| COALFIELDS. | 1904 | | 1905 | | 1906 | | 1907 | |
|---|---|---|---|---|---|---|---|---|
| | Statute Tons. | Per cent of Indian Total. | Statute Tons. | Per cent of Indian Total. | Statute Tons. | Per cent of Indian Total. | Statute Tons. | Per cent of Indian Total. |
| *Baluchistan*— | | | | | | | | |
| Khost | 38,574 | ·47 | 34,140 | ·41 | 32,500 | ·33 | 29,378 | ·26 |
| Sor Range, Mach, etc. | 11,293 | ·14 | 7,585 | ·09 | 9,664 | ·10 | 13,110 | ·12 |
| *Burma*— | | | | | | | | |
| Shwebo | 1,105 | ·02 | *Nil* | .. | .. | .. | *Nil* | .. |
| Upper Chindwin | *Nil* | | *Nil* | .. | 1,222 | ·01 | *Nil* | .. |
| *Kashmir*— | | | | | | | | |
| Ladda | 270 | | *Nil* | .. | .. | .. | *Nil* | |
| *Eastern Bengal and Assam*— | | | | | | | | |
| Makum | 266,265 | 3·25 | 276,577 | ·29 | 285,402 | 2·92 | 295,695 | 2·65 |
| Smaller fields | 500 | | 488 | | 88 | | 100 | |
| *Punjab*— | | | | | | | | |
| Salt Range | 45,258 | ·55 | 61,618 | ·75 | 57,438 | ·75 | 47,298 | ·55 |
| Attock district | 336 | | 715 | | 10 | | .. | |
| Shahpur „ | .. | .. | 289 | | 15,671 | | 12,686 | |
| Mianwali | .. | .. | .. | .. | .. | .. | 765 | .. |
| *Rajputana*— | | | | | | | | |
| Bikanir | 45,078 | ·55 | 42,964 | ·51 | 32,372 | ·33 | 28,062 | ·25 |
| TOTAL | 408,679 | 4·98 | 424,376 | 5·05 | 434,367 | 4·44 | 427,094 | 3·83 |

**Exports and Imports.** The external trade in coal shows for the past year a drop in exports, from over one million tons in 1906 to 658,145 tons in 1907 (table 8). At the same time there has been a small increase in the amount of foreign coal imported into India, from 232,947 tons in 1906 to 302,807 tons in 1907. The change in these figures is due to the increased demand for coal in India being even in excess of the largely increased production. Table 9 shows that, in 1907, the consumption of Indian coal in the country amounted to 94 per cent of the total output.

TABLE 8.—*Exports of Indian Coal and Coke during 1903—1907.*

| Exported to | 1903 | 1904 | 1905 | 1906 | 1907 |
|---|---|---|---|---|---|
| | Tons. | Tons. | Tons. | Tons. | Tons. |
| Aden | 31,210 | 31,620 | 29,312 | 19,233 | 13,835 |
| East Africa | 30,645 | 21,263 | 15,034 | 13,532 | 7,787 |
| Ceylon | 252,912 | 360,697 | 376,853 | 416,191 | 320,735 |
| Straits Settlements | 111,520 | 144,545 | 229,230 | 317,655 | 202,445 |
| Sumatra | 10,993 | 32,810 | 33,859 | 71,482 | 84,337 |
| China | 4,668 | 11,875 | 81,762 | 133,752 | 11,266 |
| Other Countries | | | 16,983 | 31,106 | 17,740 |
| TOTAL | 441,948 | 602,810 | 783,033 | 1,002,951 | 658,145 |

TABLE 9.—*Relation of Consumption to Production of Coal during 1904—1907.*

| YEAR. | Total Consumption of Coal in India.* | Consumption of Indian Coal in India. | |
|---|---|---|---|
| | | Quantity. | *Percentage of Indian Production.* |
| | Statute Tons. | Statute Tons. | |
| 1904 | 7,884,140 | 7,613,896 | *92·7* |
| 1905 | 7,847,281 | 7,634,706 | *90·7* |
| 1906 | 9,013,246 | 8,780,299 | *89·7* |
| 1907 | 10,792,001 | 10,489,194 | *94·1* |

* Including Government Stores.

**Consumption of Coal on Railways.**

Table 10 shows a gradual increase in the consumption of both Indian and foreign coal on the railways, the total in 1907 being 3,398,080 tons. Of this total, 98·4 per cent. was of Indian origin, the proportion of the Indian production consumed on the railways being still about 30 per cent.

TABLE 10.—*Coal consumed on Indian Railways during the five years 1903—1907.*

| YEAR. | Indian Coal. | | | Foreign Coal. | | Total Consumption. |
|---|---|---|---|---|---|---|
| | Quantity. | *Per cent. of Total.* | Per cent. of Indian output. | Quantity. | *Per cent. of Total* | |
| | Tons. | | | Tons. | | |
| 1903 . . . | 2,203,889 | *99·2* | 29·6 | 17,696 | *0·8* | **2,221,585** |
| 1904 . . . | 2,447,341 | *99·3* | 29·8 | 17,432 | *0·7* | **2,464,773** |
| 1905 . . . | 2,668,424 | *99·3* | 31·7 | 18,235 | *0·7* | **2,686,659** |
| 1906 . . . | 2,878.281 | *98·7* | 29·4 | 37,280 | *1·3* | **2,915,561** |
| 1907 . . . | 3,343,219 | *98·4* | 29·9 | 54,861 | *1·6* | **3,398,080** |

**Labour Statistics.**

Tables 11 to 15 briefly indicate the labour statistics on Indian coal mines. There has been an increase in the number of workers from 92,740 in 1904 to 112,502 employed on an average daily during 1907. With the gradual improvement in mining methods, there has been an increase in the output of coal per person employed, but a part of this apparent increase in efficiency is due to an improvement in the system of keeping statistics by the coal-mine Managers. The increase in the output per person employed below ground, as shown in table 12, is especially marked, for the improvements that have occurred in mining have mainly affected the system of under-ground working. During 1907, 73,191 persons were employed on an average daily below ground, the output of coal being over 152 tons per person employed. This is still a low degree of efficiency compared to that of countries employing European labour;

but the low efficiency shown by the statistical method indicates one pleasing feature in connection with Indian coal mines that does not appear in the returns: at present large numbers of women and children find congenial and light employment on the surface and in shallow workings; this feature of the coal-mining industry will be reduced with the increased use of machinery and the development of more strenuous methods less profitable and less pleasurable to many of the colliery workers.

TABLE 11.—*Output of Coal per person employed at Mines during the years 1904—1907.*

| YEAR. | Average daily attendance of Workers. | Output. | *Output per person employed.* |
|---|---|---|---|
| | | Statute Tons. | *Statute Tons.* |
| 1904 . . . . . . | 92,740 | 8,216,706 | *88·6* |
| 1905 . . . . . . | 89,995 | 8,417,739 | *93·5* |
| 1906 . . . . . . | 99,138 | 9,783,250 | *98·6* |
| 1907 . . . . . . | 112,502 | 11,147,339 | *99·1* |

TABLE 12.—*Output of Coal per person employed Below Ground during 1904—1907.*

| YEAR. | Average Number of persons employed daily below ground. | Output. | *Output per person employed below ground.* |
|---|---|---|---|
| | | Statute Tons. | *Statute Tons.* |
| 1904 . . . . . . | 64,969 | 8,216,706 | *126·4* |
| 1905 . . . . . . | 61,616 | 8,417,739 | *136·6* |
| 1906 . . . . . . | 67,456 | 9,783,250 | *145·0* |
| 1907 . . . . . . | 73,191 | 11,147,339 | *152·3* |

**Colliery Accidents.**

The increased dangers, due to deeper and more complex mining operations, have been attended by greater efficiency in management throughout, with the result that the death-rate from colliery accidents shows no marked increase, and in 1907 was still at the low rate of ·89 per thousand employed—a rate that compares favourably with all other coal-mining countries. The death-rate in the United Kingdom, during 1907, from accidents at mines under the Coal Mines Act, was 1·32 per thousand employed, while at metalliferous mines the rate was 1·08, and inside pits and excavations under the Quarries Act 1·34 per thousand. Official figures for most foreign countries are not yet available beyond the year 1905. During that year, the average death-rate per thousand persons employed at coal mines was 1·34 for the British Empire and 2·40 for foreign countries, making an average for the coal mines of the world of 2·01 deaths per thousand persons employed, as compared with 1·85 in 1904. In the United States, which is by far the largest coal-producing country in the world, the death-rate from colliery accidents per thousand persons employed was 3·35 in 1904 and 3·45 in 1905. According to F. L. Hoffman,[1] the average rate at the coal mines of North America for the ten years 1897—1906 was 3·14 per 1,000.

TABLE 13.—*Death-rate from Colliery Accidents, below and above ground, during 1904—1907.*

| YEAR. | Average Number of persons employed. | Deaths from Accidents. | *Death-rate per 1,000 employed.* |
|---|---|---|---|
| 1904 . . . . . . | 92,740 | 67 | ·72 |
| 1905 . . . . . . | 89,995 | 72 | ·80 |
| 1906 . . . . . . | 99,138 | 99 | ·99 |
| 1907 . . . . . . | 112,502 | 101 | ·89 |

[1] *New York Eng. and Min. Journ.*, Vol. 85, p. 34, Jan. 4th, 1908.

TABLE 14.—*Comparison of Coal-Production and Deaths from Colliery Accidents in 1904—1907.*

| YEAR. | Deaths from Colliery Accidents. | Output of Coal. | *Tons of Coal raised per person killed.* |
|---|---|---|---|
| 1904 . . . . . . | 67 | 8,216,706 | *122,637* |
| 1905 . . . . . . | 72 | 8,417,739 | *116,913* |
| 1906 . . . . . . | 99 | 9,783,250 | *98,821* |
| 1907 . . . . . . | 101 | 11,147,339 | *110,369* |

As in previous years there is a slightly higher death-rate from colliery accidents in Native States than in mines under the control of the Indian Mines Act. During 1907, the death-rate per thousand at mines under the Act was only 0·86, while in Native States the rate was 1·22. The figures for the previous three years of the current quinquennial period are shown in table 15.

TABLE 15.—*Comparison of Death-rate from Accidents at Coal Mines worked under the Mines Act of 1901 with those in Native States during 1904—1907.*

| YEAR. | Average number of persons employed daily. | | *Deaths from Accidents.* | | Death rate per 1,000 persons employed. | |
|---|---|---|---|---|---|---|
| | Mines under the Act. | *Native States.* | Mines under the Act. | *Native States.* | Mines under the Act. | *Native States.* |
| 1904 . . | 82,002 | *10 683* | 55 | *12* | ·67 | *1·12* |
| 1905 . . | 80,406 | *9 498* | 58 | *14* | ·72 | *1·47* |
| 1906 . . | 90,150 | *8 979* | 80 | *19* | ·88 | *2·11* |
| 1907 . . | 102,689 | *9,813* | 89 | *12* | ·86 | *1·22* |

## Diamonds.

It is reported that a certain number of diamonds are picked up in the neighbourhood of Wajra Karur in the Anantapur district of the Madras Presidency, but no statistics are obtainable as to the actual production.

The only figures returned for diamonds relate to the production in the States of Panna, Charkhari and Ajaigarh in Central India. The production for the past four years is shown in table 16, the output for 1907 being more nearly in agreement with the average for past years. The daily average attendance of the workers on the diamond fields is returned as 1,084 in 1907, against 2,051 during 1906.

TABLE 16.—*Production of Diamonds in Central India.*

| YEAR. | Quantity. | *Value.* |
|---|---|---|
| | Carats. | £ |
| 1904 . . . . . . . . | 286·48 | *2,686* |
| 1905 . . . . . . . . | 172·41 | *2,474* |
| 1906 . . . . . . . . | 305·91 | *5,160* |
| 1907 . . . . . . . . | 628·00 | *2,784* |

## Gold.

The figures for gold production are shown in table 17. It will be noticed that, during the past three years, there has been a slight decline in the output from the Mysore gold mines which, however, still dominate the total. Work in the Dharwar area appears to have passed the prospecting stage, the production in 1907 being valued at £18,634. There has also been an increase in the amount of gold obtained by alluvial dredging in the Upper Irrawaddy river, Burma. The company operating in this area received sanction during the year to alter the boundaries of its concession, relinquishing the lower 15 miles of the area leased in exchange for an equivalent stretch divided between the two tributary rivers about the confluence.

The output of gold from the Hutti mines in the Nizam's Dominions is shown separately in table 18. During the past three years, the production has been valued at a little over £50,000 per annum, and the total output since operations commenced in 1903 is valued at £280,206.

TABLE 17.—*Quantity and Value of Gold produced in India during 1904—1907.*

| PROVINCE. | 1904 | | 1905 | | 1906 | | 1907 | |
|---|---|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| | Ounces | £ | Ounces | £ | Ounces | £ | Ounces | £ |
| *Bombay*— | | | | | | | | |
| Dharwar . . | .. | .. | 93 | 321 | 60 | 232 | 4,017 | 18,634 |
| *Burma*— | | | | | | | | |
| Pakokku . . | .. | .. | 1½ | 7 | 1·3 | 5 | 1 | 4 |
| Myitkyina . . | 216 | 810 | 620 | 2,412 | 2,300 | 8,850 | 3,837 | 14,919 |
| *Hyderabad* . . | 10,559 | 40,624 | 13,167 | 50,060 | 13,782 | 52,901 | 13,383 | 50,216 |
| *Mysore* . . . | 607,578 | 2,323,183 | 616,758 | 2,363,457 | 565,208 | 2,167,636 | 535,085 | 2,049,268 |
| *Punjab* . . . | 370 | 1,379 | 176 | 703 | 190 | 746 | 163 | 639 |
| *United Provinces* . | 23 | 83 | 2½ | 11 | 3·8 | 14 | 2 | 11 |
| TOTAL . | 618,746 | 2,366,079 | 630,818 | 2,416,971 | 581,545 | 2,230,284 | 556,488 | 2,133,691 |

TABLE 18.—*Output of Gold from the Hutti Mine, Hyderabad.*

| YEAR. | Quantity. | Value. |
|---|---|---|
| | Ounces | £ |
| 1903 | 3,809 | *14,505* |
| 1904 | 10,559 | *40,624* |
| 1905 | 13,167 | *50,060* |
| 1906 | 13,784 | *52,801* |
| 1907 | 13,383 | *50,216* |
| TOTAL | 54,702 | *208,206* |

## Graphite.

The graphite deposits in Travancore State are still the only occurrences of the mineral which are being worked systematically. The annual output varies between 2,000 and 3,000 tons, but the value returned for 1907 was distinctly lower than the reported value of previous years, amounting only to £7,387. The yearly figures are shown in table 19. The average number of persons employed daily at the Travancore graphite mines was 485 in 1907 as against 494 in the previous year.

TABLE 19.—*Production of Graphite during 1904—1907.*

| YEAR. | Quantity. | Value. |
|---|---|---|
| | Tons. | £ |
| 1904 | 3,256 | *16,726* |
| 1905 | 2,324 | *16,890* |
| 1906 | 2,600 | *10,009* |
| 1907 | 2,433 | *7,387* |

## Iron-Ore.

There was again a decrease in the output of iron-ore during 1907, the total amount raised being 67,667 tons compared with 74,120 tons in 1906. In consequence, however, of the exploitation of the richer iron-ore deposits in the Singhbhum area, the value returned for 1907 was greater than that reported during the year before. The year 1907 marks what will probably be an im-

portant stage in the history of iron-manufacture in India, for, during the month of July a new company was floated at Bombay, known as the Tata Iron and Steel Company, Limited, with a capital of 2⅛ crores of rupees. The company has secured the lease of 20 square miles of iron-ore lands in the Mourbhanj State, Orissa, and a considerable area in the Raipur district of the Central Provinces. As a site for the new works, 22 square miles of land have been secured in the Dhalbhum estate at the junction of the Subarnarekha and Khorkai rivers near Kalimati on the Bengal Nagpur Railway. Sanction has been given for the construction of a railway from the works near Kalimati to the ore-fields in Mourbhanj, and land has been purchased in the Jherria coalfield for the development of the necessary collieries, while limestone quarries have been secured in the Jubbulpore district. Considerable progress has been made in preparing the site for the erection of blast-furnaces and steel-rolling mills, and it is expected that actual production will commence early in 1910. Hitherto, the only successful iron-smelting works in India, conducted on European lines, have been those belonging to the Bengal Iron and Steel Company at Barakar in Bengal. The production of the latter company is limited to pig-iron, although an experiment was made in steel-manufacture in 1906. The Tata Company, however, proposes to make steel production its chief object.

The ancient industry of producing malleable iron in small bloomeries is more persistent in the Central Provinces than most other areas. During 1907, 451 small furnaces were at work, but the amount of iron turned out cannot be estimated with any precision.

TABLE 20.—*Quantity and Value of Iron-ore raised during the years 1904—1907.*

| PROVINCE. | 1904 | | 1905 | | 1906 | | 1907 | |
|---|---|---|---|---|---|---|---|---|
| | Quantity. | *Value.* | Quantity. | *Value.* | Quantity. | *Value.* | Quantity. | *Value.* |
| | Tons | £ | Tons | £ | Tons | £ | Tons | £ |
| Bengal | 65,115 | *9,698* | 97,698 | *12.538* | 69,397 | *10.085* | 65,524 | *12,810* |
| Other Provinces and States | 6,541 | *1,744* | 4.837 | *1.290* | 4,723 | *1 259* | 2.143* | *571* |
| **TOTAL, Statute Tons and £** | **71,656** | ***11,442*** | **102,535** | ***13,828*** | **74.120** | ***11.344*** | **67,667** | ***13 381*** |
| *Total, Metric Tons.* | *72,802* | | *10 ,175* | | *75,306* | | *68,750* | |

* Exclusive of the production in Mysore not yet reported (July 11th, 1908).

## Jadeite.

According to returns furnished by the Deputy Commissioner of Myitkyina district in Upper Burma, the jadeite raised during 1907 amounted to 3,590 cwts., valued locally at £18,998. The average daily attendance of workers occupied with this industry was 1,356 during the year 1907. Part of the jadeite produced in Upper Burma is absorbed locally, part of it is carried overland into the markets of south-west China, and the remainder goes through the port of Rangoon mainly for the Chinese market. Table 21 shows the quantity and value of jadeite exported through Rangoon during the past five years. The average amount is returned as 2,521 cwts., valued at £50,416, thus showing an average value per cwt. of £20. A detailed account of the geological relationships of the Myitkyina jadeite, by Dr. A. W. G. Bleeck, is published in Records, Vol. XXXVI, Part 4. A summary of Dr. Bleeck's results is given in the General Report for 1907 (*supra*, p. 16).

TABLE 21.—*Exports of Jadestone through Rangoon during the years 1903—1907.*

| YEAR. | Weight. | *Value.* | Value per cwt. |
|---|---|---|---|
| | Cwts | £ | £ |
| 1903 . . . . . . | 2,192 | *50,582* | 23·08 |
| 1904 . . . . . . | 2,869 | *43,946* | 15·32 |
| 1905 . . . . . . | 2,342 | *43,474* | 18·56 |
| 1906 . . . . . . | 2,566 | *64,433* | 25·11 |
| 1907 . . . . . . | 2,636 | *49,643* | 18·83 |
| **Average . .** | **2,521** | **50,416** | **20·00** |

## Magnesite.

The only occurrence of magnesite being worked is that of the Chalk Hills near Salem, Madras Presidency. The quantity raised during 1907 was considerably less than in the previous three years of the current quinquennial period, and the Company has evidently not yet found a full outlet for the remarkably pure mineral

it is able to raise. The figures for output and value are shown in table 22. A lease for mining magnesite has been granted in Karuppur and three other villages in the Salem district, but no work has so far been done in this new area. Prospecting operations have also been undertaken in parts of Mysore State, where magnesite occurs as an alteration product of peridotite rocks. A considerable development of these rocks with magnesite occurs near Seringala, north of Fraserpet in Coorg, but the area is far from the railway systems.

TABLE 22.—*Production of Magnesite in the Chalk Hills near Salem during 1904—1907.*

| YEAR. | Quantity. | *Value.* (*a*) |
|---|---|---|
| | Tons. | £ |
| 1904 | 1,315 | *351* |
| 1905 | 2,063 | *550* |
| 1906 | 1,832 | *488* |
| 1907 | 186 | *50* |

(*a*) Value estimated at Rs. 4 a ton for all years.

## Manganese-ore.

The conspicuous increase in the production of manganese-ore during 1906 was overshadowed by a still larger output in 1907. The high prices prevailing during the earlier part of the year began to drop rapidly towards the end, and, before December, the market rates for first-grade manganese-ore carrying over 50 per cent. of the metal had fallen below 1*s*. a unit. There has, consequently, been a check in the production in most areas and an almost complete cessation of mining for the lower grades of ore at mines far removed from the railways. The total production reported for 1907 reached the extraordinary figure of 898,345 tons, against the previous record of 495,730 tons during 1906. The returns for 1907 show an export of only 581,035 tons of ore. It thus appears probable that considerable stocks have been accumulated at the mines.

The average number of persons employed daily at manganese mines under the control of the Indian Mines Act was 18,751 in 1907 as against 11,273 in 1906. The provincial production of

manganese-ore for the past four years is shown in table 23, from which it will be seen that the mines in the Central Provinces have considerably increased their lead over those in the other provinces. The district production of manganese-ore in the Central Provinces is shown in table 23(A), showing that by far the largest output was obtained from the Bhandara district.

TABLE 23.—*Production of Manganese-ore for 1904—1907.*

| PROVINCE. | 1904 | 1905 | 1906 | 1907 |
|---|---|---|---|---|
| | Statute Tons. | Statute Tons. | Statute Tons. | Statute Tons. |
| Bengal | .. | .. | .. | 2,000 |
| Bombay | .. | .. | 7,517 | 22,125 |
| Central India | 11,564 | 30,251 | 50,074 | 35,743 |
| Central Provinces | 85,034 | 159,950 | 320,759 | 686,572 |
| Madras | 53,699 | 63,695 | 117,380 | 151,890 |
| **TOTAL, Statute Tons** | **150,297** | **253,896** | **495,730** | **898,345(*a*)** |
| *Total, Metric Tons* | *152,708* | *257,969* | *503,684* | *912,718* |

(*a*) Including 15 tons extracted in Las Bela, Baluchistan, under a prospecting license.

TABLE 23(A).—*Production of Manganese-ore in the Central Provinces during the year 1907.*

| DISTRICT. | From mines under the Indian Mines Act. | From mines that do not come under the Indian Mines Act. | TOTAL. |
|---|---|---|---|
| | Statute Tons. | Statute Tons. | Statute Tons. |
| Balaghat | 161,047 | 6,666 | **167,713** |
| Bhandara | 141,183 | 144,065 | **285,248** |
| Chhindwara | 12,468 | 12,468 | **24,936** |
| Nagpur | 181,875 | 26,800 | **208,675** |

## Mica.

The final figures for the provincial production of mica have not yet been received, but the export returns show a considerable drop in the quantity sent out of India, with a similar decline in the total value. The value for 1907, however, is considerably greater than that reported in any previous year except 1906, and the average value of a cwt., *viz.*, £5-8-0, shows that a better quality of mica was exported during the year than in any previous years.

TABLE 24.—*Exports of Mica during the five years 1903—1907.*

| YEAR. | Weight. | *Value.* | Value per cwt. |
|---|---|---|---|
| | Cwt. | £ | £ |
| 1903 . . . . . . | 22,106 | *90,297* | 4·09 |
| 1904 . . . . . . | 18,250 | *83,183* | 4·56 |
| 1905 . . . . . . | 25,837 | *142,008* | 5·50 |
| 1906 . . . . . . | 54,262 | *259,543* | 4·78 |
| 1907 . . . . . . | 39,055 | *226,382* | 5·80 |

TABLE 25.—*Provincial Production of Mica for 1904—1907.*

| PROVINCE. | 1904 | 1905 | 1906 | 1907 |
|---|---|---|---|---|
| | Cwts. | Cwts. | Cwts. | Cwts. |
| Bengal . . . . . | 16,520 | 14,601 | 22,360 | 28,579 |
| Madras . . . . . | 4,840 | 8,280 | 24,420 | |
| Rajputana . . . . . | 804 | 2,760 | 5,763 | 7,759 |
| TOTAL . | 22,164 | 25,641 | 52,543 | |

## Petroleum.

There was a satisfactory increase in the production of petroleum during the year, the total (152,045,677 gallons) being greater than any production previously reported. The figures for the past four years are shown in table 26, from which it will be seen that

there has been an increase in all three producing provinces, although obviously changes in Assam and the Punjab are unimportant compared to the variations in Burma.

TABLE 26.—*Production of Petroleum during 1904—1907.*

| PROVINCE. | 1904 | 1905 | 1906 | 1907 |
|---|---|---|---|---|
| | Gallons. | Gallons. | Gallons. | Gallons. |
| Burma . . . . | 115,903,804 | 142,063,846 | 137,654,261 | 148,888,002 |
| Eastern Bengal and Assam . | 2,585,920 | 2,733,110 | 2,897,990 | 3,156,665 |
| Punjab . . . | 1,658 | 1,488 | 871 | 1,010 |
| TOTAL . | 118,491,382 | 144,798,444 | 140,553,122 | 152,045,677 |

In table 27, the district production of the Burma oil-fields is shown for the past four years. It will be noticed that there has been a serious decline in the output from the Yenangyat field in the Pakokku district, but considerable increases are shown in the Singu field of Myingyan and Yenangyaung in Magwe. The total production in Burma during 1907 was nearly 149 million gallons. The average number of persons employed daily on the Burma oil-fields was 2,380 in 1907, against 1,837 in 1906.

**Burma Oil-fields.**

TABLE 27.—*Production of the Burma Oil-fields for 1904—1907.*

| OIL-FIELD AND DISTRICT. | 1904 | 1905 | 1906 | 1907 |
|---|---|---|---|---|
| | Gallons. | Gallons. | Gallons. | Gallons. |
| Akyab . . . | 47,082 | 53,455 | 35,423 | 28,877 |
| Kyaukphyu . . | 89,827 | 60,647 | 53,429 | 49,587 |
| Yenangyaung, Magwe | 73,428,960 | 85,648,749 | 89,549,252 | 96,857,519 |
| Singu, Myingyan . | 23,677,450 | 37,541,177 | 34,843,621 | 43,543,566 |
| Yenangyat, Pakokku | 18,660,485 | 18,759,818 | 13,172,136 | 8,407,825 |
| Thayetmyo . . | .. | .. | 400 | 628 |
| TOTAL . | 115,903,804 | 142,063,846 | 137,654,261 | 148,888,002 |

**Imports and Exports.**

The imports and exports of mineral oil and paraffin wax are shown in tables 28 and 29. It will be noticed that, in consequence of the resumption of more normal conditions in Russia, kerosene of Russian origin has again been imported in considerable quantities, the total amount of kerosene imported during 1907 having risen to the figure reported for 1905. The combined production and importation of mineral oil is greatly in excess of that recorded for previous years, but is not entirely due to consumption in the country, as large quantities of liquid fuel prepared in Burma have also been exported.

TABLE 28.—*Imports of Kerosene during the five years 1903—1907.*

| Imported from | 1903 | 1904 | 1905 | 1906 | 1907 |
|---|---|---|---|---|---|
| | Gallons. | Gallons. | Gallons. | Gallons. | Gallons. |
| Russia . . | 65,434,324 | 42,256,738 | 17,205,175 | .. | 10,569,817 |
| United States . | 7,588,569 | 7,628,275 | 18,737,577 | 28,494,794 | 22,499,053 |
| Borneo . . | 1,078,719 | 6,931,291 | 7,039,812 | 1,795,715 | 6,577,826 |
| Straits Settlements . . | 1,280,507 | 8,985,538 | 12,508,844 | 8,499,198 | 6,805,864 |
| Sumatra . . | 974,981 | 3,566,619 | 6,816,991 | 9,733,349 | 3,951,321 |
| Other Countries | 4,479 | 1,222,397 | 16,363 | 7,638 | 11,903,165 |
| **TOTAL** . | **76,361,579** | **70,590,858** | **62,324,762** | **48,530,694** | **62,307,046** |

TABLE 29.—*Exports of Mineral Oil and Paraffin Wax during the five years 1903—1907.*

| YEAR. | Mineral oil. | Paraffin wax. |
|---|---|---|
| | Gallons. | Cwts. |
| 1903 . . . . . . . . | 747,834 | 43,206 |
| 1904 . . . . . . . | 3,787,677 | 42,940 |
| 1905 . . . . . . . . | 2,422,589 | 63,966 |
| 1906 . . . . . . . . | 903,545 | 61,097 |
| 1907 . . . . . . . . | 1,764,075 | 76,075 |

## Ruby, Sapphire and Spinel.

The total value of rubies, sapphires and spinels produced during the year amounted to £98,258, rubies alone being valued at £93,428. More extended work was carried on at the sapphire mines in Kashmir, and large quantities of lower quality stones were obtained in addition to a few stones of very high value. The total value of the stones recovered in Kashmir during 1907 was estimated to be £3,144. In the ruby mines districts of Upper Burma, 2,188 persons were employed on an average daily during 1907, against 2,367 in 1906.

TABLE 30.—*Production of Ruby, Sapphire and Spinel during the years 1904—1907.*

| PROVINCE. | 1904. | | 1905. | | 1906. | | 1907. | |
|---|---|---|---|---|---|---|---|---|
| | Quantity | *Value.* | Quantity | *Value.* | Quantity | *Value.* | Quantity | *Value.* |
| | Carats. | £ | Carats. | £ | Carats. | £ | Carats. | £ |
| Burma . . | 265,901 | *90,612* | 266,584 | *88,840* | 326,855 | *95,540* | 334,535 | *95,114* |
| Kashmir . | .. | .. | .. | .. | 2,837 | *1,327* | 305,682 | *3,144* |
| TOTAL, Carats and £ . | 265,901 | *90,612* | 266,584 | *88,840* | 329,692 | *96,867* | 640,217 | *98,258* |

## Salt.

During the past four years the production of salt has been well in excess of the average for previous years, although for 1907 the total, 1,193,168 tons, was below those of 1905 and 1906. Table 31 shows the provincial returns for the past four years. The figures for rock-salt, shown separately in table 32, indicate no important change.

TABLE 31.—*Provincial Production of Salt during 1904—1907.*

| PROVINCE. | 1904. | 1905. | 1906. | 1907. |
|---|---|---|---|---|
| | Statute Tons. | Statute Tons. | Statute Tons. | Statute Tons. |
| Aden | 66,007 | 97,727 | 67,535 | 90,385 |
| Bengal | 88 | 3 | 61 | 26 |
| Bombay | 430,409 | 425,090 | 390,535 | 385,441 |
| Burma | 21,387 | 23,132 | 29,847 | 30,022 |
| Gwalior State | 374 | 84 | 249 | 189 |
| Madras | 356,834 | 388,646 | 412,717 | 353,271 |
| Northern India | 282,421 | 342,190 | 312,559 | 320,689 |
| Sind | 13,540 | 14,265 | 11,777 | 13,145 |
| **TOTAL, Statute Tons** | **1,171,060** | **1,291,137** | **1,225,280** | **1,193,168** |
| *Total, Metric Tons* | *1,188,900* | *1,311,856* | *1,244,939* | *1,212,258* |

TABLE 32.—*Production of Rock-Salt during 1904—1907.*

| —— | 1904. | 1905. | 1906. | 1907. |
|---|---|---|---|---|
| | Statute Tons. | Statute Tons. | Statute Tons. | Statute Tons. |
| Salt Range, Punjab | 107,403 | 94,048 | 107,194 | 101,779 |
| Kohat | 16,664 | 14,897 | 13,436 | 17,228 |
| Mandi | 4,507 | 3,571 | 3,609 | 4,085 |
| **TOTAL, Statute Tons** | **128,574** | **112,516** | **124,239** | **123,092** |
| *Total, Metric Tons* | *130,635* | *114,316* | *126,233* | *125,061* |

## Saltpetre.

The figures for export by sea are accepted in these annual statements as a sufficient indication of the saltpetre industry. The comparatively small quantities involved in trans-frontier trade

will be taken into account in the Quinquennial Review. No definite change in the trade is shown by the figures for the past five years, though the average amount exported, 364,305 cwts., is below the average for the preceding five years.

TABLE 33.—*Exports of Saltpetre during the five years 1903—1907.*

| YEAR. | Weight. | *Value.* | Value per cwt. |
|---|---|---|---|
| | Cwts. | £ | Shillings. |
| 1903 . . . . . . | 412,593 | *290,196* | 14·1 |
| 1904 . . . . . . | 390,970 | *266,349* | 13·6 |
| 1905 . . . . . . | 313,122 | *235,723* | 15·1 |
| 1906 . . . . . . | 347,251 | *270,547* | 15·6 |
| 1907 . . . . . . | 357,589 | *274,679* | 15·4 |
| *Average* . | *364,305* | *267,499* | 14·6 |

## Tin-ore.

The returns for production show no material change in the tin-mining industry in South Burma. During the past two years, however, concessions have been granted for mining on European lines, and attempts are being made to treat the alluvial deposits by hydraulic mining. A geological survey of the Mergui district, commenced during 1907, shows that tin-ore is very widely distributed, and, although apparently not concentrated into very rich deposits, there should be material available for a much larger industry than that which now continues in an uncertain way by unsystematic " washings " conducted mainly by Chinese immigrants. Any information regarding the mineral resources of a district so thickly clothed with jungle-vegetation and rock decomposition products must necessarily be without precision, but enough is exposed to show that the country is highly mineralised along the contact zone between the older sedimentary rocks and the intruded masses of granite. Details should be available before the Quinquennial Review, to be issued next year, is closed.

TABLE 34.—*Production of Tin-ore in Burma during 1904—1907.*

| YEAR. | Quantity. | *Value.* |
|---|---|---|
| | Cwts. | £ |
| 1904 . . . . . . . | 1,414 | *8,353* |
| 1905 . . . . . . . | 1,527 | *9,916* |
| 1906 . . . . . . . | 1,919 | *13,799* |
| 1907 . . . . . . . | 1,584 | *11,882* |

## III. MINERALS OF GROUP II.

The following notes deal with minerals for which returns of production are obtainable in certain areas only.

**Alum.**

The figures for alum production in the Mianwali district, Punjab, are shown in table 35. The great variations from year to year show that the industry is far from "established", and consequently a special survey of the conditions governing the manufacture of alum in this district has been undertaken. The results of this investigation will probably be ready before the close of the present year.

TABLE 35.—*Production of Alum in Mianwali District during 1904—1907.*

| YEAR. | Quantity. | *Value.* |
|---|---|---|
| | Cwts. | £ |
| 1904 . . . . . . . . | 2,580 | *700* |
| 1905 . . . . . . . . | 7,126 | *2,038* |
| 1906 . . . . . . . . | 11,022 | *4,000* |
| 1907 . . . . . . . . | 5,511 | *2,500* |

Alum is produced in a small way and fitful manner in other districts, but the total production is small compared to the consumption, and consequently large quantities of alum are imported from Europe. During the past three years the amount of alum imported has ranged about 70,000 cwts. with an annual value of £20,000.

**Amber.**

The amber produced in the Myitkyina district of Upper Burma amounted in 1907 to 44 cwts. only, valued locally at £385.

**Borax.**

Borax is not produced within British territory, but the mineral is of interest on account of the fact that the principal part of the mineral produced on the other side of the Tibetan frontier is brought into India, and much of it in this way is passed into foreign markets.

There was a larger export than usual in 1907, amounting to 7,340 cwts., valued at £10,002, against an average export of 5,135 cwts., valued at £6,866, for the past five years, and 4,481 cwts. for the preceding five years. The amount exported by sea is not a third of the quantity brought across the frontier.

TABLE 36.—*Exports of Borax during the five years 1903—1907.*

| YEAR. | Weight. | *Value.* | Value per cwt. |
|---|---|---|---|
| | Cwts. | £ | Shillings. |
| 1903 . . . . | 5,674 | *7,797* | 27·5 |
| 1904 . . . . | 4,246 | *5,419* | 25·5 |
| 1905 . . . . | 4,198 | *5,246* | 25·0 |
| 1906 . . . . | 4,220 | *5,868* | 27·2 |
| 1907 . . . . | 7,340 | *10,002* | 27·2 |
| *Average* | *5,135* | 6,866 | *26·7* |

**Building Stone.**

Building stone of all sorts is raised in most districts outside the great alluvial tracts, but only rough estimates of quantities are generally obtainable. Returns are, however, regularly kept for the important industry of quarrying the fine Vindhyan sandstones of the Mirzapur district, where the production in 1907 amounted to 103,514 tons, valued at £12,458, against 101,745 tons, valued at £12,690, in 1906.

**Corundum.**

The well-known corundum deposits of Pipra in Rewa have been attacked by prospectors, and during the year 28 tons of the mineral were taken out for experimental purposes.

**Garnet.**

No important changes have been recorded in the garnet-mining industry of Jaipur and Kishengarh in Rajputana. The returns for 1907 show total production of 90 cwts., valued at £759.

**Limestone.**

Limestone is raised in many districts of India and Burma, some of it quarried from massive formations like the nummulitic limestone of Assam and the North-West Himalayas, and the Vindhyan beds quarried at Kutni in Jubbulpore and Sutna in Rewa. Output returns are obtained yearly from certain of the provinces only. The production in Burma during 1907 amounted to 28,152 tons; that for the Central Provinces, 72,022 tons; for Eastern Bengal and Assam, 82,449 tons, and for Rajputana, 10,642 tons. These are the principal productions of ordinary limestone; but large quantities of the concretionary *kankar* are obtained from the alluvial areas in many districts for use as road-metal and the manufacture of mortar.

The production of marble at the well-known Makrana quarries in Marwar (Jodhpur), Rajputana, is shown separately in table 37.

TABLE 37.—*Production of Marble in Jodhpur, Rajputana, during 1904—1907.*

| YEAR. | Quantity. | *Value.* |
|---|---|---|
| | Tons. | £ |
| 1904 . . . . . . . | 1,034 | *1,102* |
| 1905 . . . . . . . | 1,726 | *1,840* |
| 1906 . . . . . . . | 1,500 | *1,665* |
| 1907 . . . . . . . | 2,571 | *1,494* |

**Slate.**

Slate is raised from the Aravalli series in Rajputana and near Rewari in the Punjab, the corresponding system of foliated rocks cropping out in the Kharakhpur hills of Monghyr district, and at numerous places along the Outer Himalayas not far from the margin of the central granitic masses. The total production returned for these areas in 1907 was 12,493 tons; but this figure is obviously incomplete, as it does not include the important quarries in the Kangra district, for which statistics will be obtained before the issue of the Quinquennial Review.

**Steatite.**

Steatite is still raised in small quantities in the Pakokku Hill Tracts and in the Minbu district, Burma. The total output in 1907 was 163 cwts., valued locally at £201. Of this total 123 cwts. were raised in the Minbu district.

**Tourmaline.**

The tourmaline raised in the Ruby Mines district of Burma amounted in 1907 to 20 lbs., valued at £293, a quantity much below the productions returned for the previous two years.

# IV.—MINERAL CONCESSIONS GRANTED.

TABLE 38.—*Statement of Mineral Concessions Granted during 1907.*

## BALUCHISTAN.

| DISTRICT OR TAHSIL. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Bolan . . | (1) S. Bahawal Khan Satakzai. | Coal . . | P. L. | 160 | 11th June 1907. | 1 year. |
| Do. . . | (2) K. B. Burjorji D. Patel, C.I.E. . . | Do. . . | M. L. | 319·98 | 1st July 1907. | 30 years. |
| Kalat Bolan | (3) Messrs. Sorabji & Co. | Do. . . | M. L. | 57·194 | 26th March 1907. | Do. |
| Kalat Degari (Tribal area) | (4) Do. do. | Do. . . | M. L. | 85 | 1st July 1907. | Do. |
| Do. | (5) S. Bahawal Khan Satakzai. | Do. . . | M. L. | 36 | Do. | Do. |
| Las Bela State | (6) Messrs. James Milne and Magnes Cotes of Bristol. | Minerals of all kinds. | E. L. | 1,088 | 23rd September 1907. | 1 year. |
| Do. | (7) Mr. L. Volkari, Secretary, on behalf of the Pabb Syndicate, Karachi. | Do. . | P. L. | 480,000 | 1st October 1907. | Do. |
| Quetta-Pishin | (8) Mr. C. R. Lindsey . | Chromite . . | M. L. | 80 | 20th January 1907. | 30 years. |
| Do. | (9) S. Pheroz Shah . | Coal . . | M. L. | 51·89 | 4th June 1907. | Do. |
| Do. | (10) Baluchistan Mining Syndicate. | Chromite . . | M. L. | 80 | 8th November 1907. | Do. |
| Zhob . . | (11) Mr. C. R. Lindsey | Do. . . | M. L. | 80 | 2nd July 1907. | Do. |

## BENGAL.

| | | | | | | |
|---|---|---|---|---|---|---|
| Burdwan . | (12) Messrs. S. T. Creet & Co. | Coal . . . | P. L. | 1,458·5 | 13th March 1907. | 1 year. |
| Gaya . . | (13) Babu Monoranjan Guha. | Mica . . | M. L. | 28·26 | 16th May 1907. | 10 years. |
| Hazaribagh . | (14) Mr. F. G. Talbot . | Do. . . | P. L. | 320 | 22nd January 1907. | 1 year. |
| Do. | (15) Mr. E. Lane . . | Do. . . | P. L. . | 40 | 3rd January 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## BENGAL.—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Hazaribagh . | (16) Babu Sunder Mull . | Mica . . | P. L. . | 144·5 | 7th March 1907. | 1 year. |
| Do. . | (17) Babu Sakti Kanta Bhattacharjee. | Do. . . . | P. L. . | 59 | Do. | Do. |
| Do. . | (18) Babu Shew Narain Lal Sett. | Do. . . | P. L. . | 53 | Do. | Do. |
| Do. . | (19) Babu Monoranjan Guha. | Do. . . . | P. L. . | 40 | 15th April 1907. | Do. |
| Do. . | (20) Babu Dyal Ram . | Do. . . . | P. L. . | 40 | 25th April 1907. | Do. |
| Do. . | (21) Mr. S. D. Philippe . | Do. . . . | P. L. . | 100·5 | 1st June 1907. | Do. |
| Do. . | (22) Babu Arjani Khan | Do. . . . | P. L. . | 5·6 | 9th July 1907. | Do. |
| Do. . | (23) Babus Nagendra Nath Ghosh and others | Do. . . . | P. L. . | 33 | 26th August 1907. | Do. |
| Do. . | (24) Messrs. Gladstone, Wyllie and Co. | Do. . . . | P. L. . | } 560 | 13th July 1907. | Do. |
| Do. . | (25) Do. do. . | Do. . . . | P. L. . | | | |
| Do. . | (26) Babu Raj Krishna Sahana. | Do. . . . | P. L. . | 112 | 9th July 1907. | Do. |
| Do. . | (27) Babus Jagarnath Ram and Dyal Ram. | Do. . . . | P. L. . | 40 | 4th July 1907. | Do. |
| Do. . | (28) Mr. F. G. Talbot . | Do. . . . | P. L. . | 120 | 24th August 1907. | Do. |
| Do. . | (29) Babu Sunder Mull . | Do. . . . | P. L. . | 4 plots | 29th October 1907. | Do. |
| Do. . | (30) Mr. J. Borer . . | Do. . . . | P. L. . | 160 | Do. . | Do. |
| Do. . | (31) Do. . | Do. . . . | P. L. | 80 | Do. . | Do. |
| Do. . | (32) Do. . . | Do. . . . | P. L. . | 40 | 19th December 1907. | Do. |
| Singhbhum . | (33) Babu Modhu Lal Doogar of Calcutta. | Manganese . | P. L. . | about 640 | 8th January 1907. | Do. |
| Do. . | (34) Do. do. . | Do. . . | P. L. . | 64 | 18th March 1907. | Do. |
| Do. . | (35) Do. do. . | Do. . . | P. L. . | 64 | 2nd February 1907. | Do. |
| Do. . | (36) Do. do. . | Do. . . | P. L. . | 448 | 1st February 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## BENGAL.—*concld.*

| District. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Singhbhum . | (37) Babu Modhu Lal Doogar of Calcutta. | Manganese . | P. L. | 12·8 | 18th March 1907. | 1 year. |
| Do. . | (38) Do. do. . | Do. . . | P. L. | 12·8 | Do. | Do. |
| Do. . | (39) Do. do. . | Do. . . | P. L. | 57·6 | Do. | Do. |
| Do. . | (40) Do. do. | Do. . . | P. L. | 44·8 | Do. | Do. |
| Do. . | (41) Do. do. . | Do. . . | P. L. | 19·2 | Do. | Do. |
| Do. . | (42) Mr. Adolph Gross mann. | Do. . . | P. L. | 2,432 | 27th May 1907. | Do. |
| Do. . | (43) Messrs. Martin and Co. | Manganese and iron-ore. | P. L. | 128 | 25th June 1907. | Do. |
| Do. . | (44) Mr. Adolph Grossmann. | Manganese . | P. L. | 64 | 29th May 1907. | Do. |
| Do. . | (45) Messrs. Martin and Co. | Iron and manganese | P. L. | 3,283·2 | 3rd September 1907. | Do. |
| Do. . | (46) Do. do. . | Iron-ore and man ganese. | P. L. | 1,728 | 17th July 1907. | Do. |
| Do. . | (47) Babu Rajendra Nath Mukherjee. | Iron and man ganese. | P. L. | 3,264 | 28th July 1907. | Do. |
| Do. . | (48) Babu Madhu Lal Doogar. | Manganese | P. L. | 6·40 | 2nd July 1907. | Do. |
| Do. . | (49) C. W. Walsh, Esq. . | Manganese and iron. | P. L. | 2,905·6 | 20th September 1907 | Do. |
| Do. . | (50) H. P. Martin, Esq. . | Manganese iron and bauxite. | P. L. | 2,892·8 | 3rd September 1907. | Do. |
| Do. . | (51) Messrs. Martin & Co. | Iron-ore . . | P. L. | 1,920 | 8th October 1907. | Do. |
| Do. . | (52) Do. do. . | Gold . . | P. L. | 1,920 | 10th October 1907. | Do. |
| Do. . | (53) Do. do. . | Manganese and iron-ore. | P. L. | 1,280 | 8th October 1907. | Do. |

## BOMBAY.

| | | | | | | |
|---|---|---|---|---|---|---|
| Belgaum . | (54) Mr. Nanabhoy F. Boyce of Gadag. | Manganese . . | E. L. | 3,022 | 1st June 1907. | 1 year. |
| Do. . | (55) Mr. Coggan, the Assignee of Mr. C. B. Oakley of Bangalore. | Do. . . | P. L. | 422 | 14th January 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## BOMBAY—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Belgaum . | (56) Mr. A. Lyons, late of the S. M. Railway, Londha. | Manganese . | P. L. . | 499 | 3rd January 1908. | 1 year. |
| Do. . | (57) Do. do. . | Do. . . | E. L. . | 2,379 | Do. . | Do. |
| Bijapur . | (58) Messrs. C. H. B. Forbes & Co., Bombay. | Do. . | E. L. . | 2,535·2 | 6th March 1907. | Do. |
| Do. . | (59) Mr. W. W. Coen . | Asbestos . . | P. L. . | 1,109 | 16th December 1907. | Do. |
| Dharwar . | (60) The Sangli Gold Mining Co., Ltd. | Gold . . | M. L. . | 506 | 1st January 1907. | 30 years. |
| Do. . | (61) The Dharwar Gold Mines, Ltd. | Do. . . | M. L. . | 1,020 | 1st March 1907. | Do. |
| Do. . | (62) Mr. W. W. Coen . | Manganese . | E. L. . | 2,420 | 12th March 1907. | 1 year. |
| Do. . | (63) Mr. Nanabhoy F. Boyce. | Gold . . | E. L. . | 3,916 | 25th April 1907. | Do. |
| Do. . | (64) Mr. Ramrao Narayan, Bellary. | Copper and mica . | E. L. . | 378 | 24th June 1907. | Do. |
| Do. . | (65) Mr. E. D. Puzey . | Gold . . | P. L. . | 422 | 14th January 1907. | Do. |
| Do. . | (66) Mr. H. F. Strickland. | Graphite and Copper | P. L. . | 1,568 | 5th September 1907. | Do. |
| Do. . | (67) Do. do. . | Gold . . | P. L. . | 1,703 | 16th July 1907. | Do. |
| Do . | (68) Mr. Nanabhoy F. Boyce. | Manganese . | E. L. . | 2,511 | 12th July 1907. | Do. |
| Do. . | (69) Mr. Abdul Kadar *alias* Fakir Mahomad Ebhrahim Khan Pathan. | Copper and lead . | P. L. . | 909 | 19th September 1907. | Do. |
| Do. . | (70) Mr. R. N. Bellary . | All minerals . | E. L. . | 218 | 2nd August 1907. | Do. |
| Do. . | (71) Mr. V. S. Sambhshiva Iyar. | Manganese . | P. L. . | 535 | 14th September 1907. | Do. |
| Do. . | (72) Mr. B. Raghavaya . | Do. . . | E. L. . | 2,429 | 18th September 1907. | Do. |
| Do. . | (73) Mr. N. B. Raichur . | Do. . . | E. L. . | 1,713 | Do. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## BOMBAY—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Dharwar . | (74) Mr. Claude Cour Palais. | Gold . . | P. L. . | 82 | 1st December 1907. | 1 year. |
| Do. . | (75) Mr. C. N. Surya Narayanrào. | Manganese . | P. L. . | 701 | 1st January 1908. | Do. |
| Do. . | (76) Mr. A. R. Chalavraya Moodliyar. | Do. . . | P. L. . | 1,401 | 25th October 1907. | Do. |
| Do. . | (77) Mr. B. Raghavaya . | Do. . . | E. L. . | 1,170 | 22nd October 1907. | Do. |
| Do. . | (78) Mr. N. B. Raichur . | Do. . . | E. L. . | 1,808 | 18th October 1907. | Do. |
| Kanara . | (79) Mr. T. B. Kantharia, on behalf of Messrs. Kiddle, Reeve & Co. | Do. . . | E. L. . | 62,534·4 | 30th March 1907. | Do. |
| Do. . | (80) Mr. C. P. Boyce . | Do. . . | E. L. . | 5,354 | Do. . | Do. |
| Do. . | (81) Mr. R. T. Coggan, Lena Mining Syndicate. | Do. . . | E. L. . | 1,614 | 21st June 1907. | Do. |
| Do. . | (82) Mr. N. F. Boyce, Gadag. | Do. . . | E. L. . | 7,668 | 24th June 1907. | Do. |
| Do. . | (83) Messrs. Killick, Nixon & Co. | Do. . . | E. L. . | 266 | 4th June 1907. | Do. |
| Do. . | (84) Mr. Shapurji N. Chandabhoy. | Do. . . | E. L. . | 850 | 29th May 1907. | Do. |
| Do. . | (85) Messrs. A. Blaschek & Co. | Do. . . | E. L. . | 89 | 11th May 1907. | Do. |
| Do. . | (86) Mr. Kashinath Ramchandra Godbole. | Do. . . | E. L. . | 1,608 | 24th June 1907. | Do. |
| Do. . | (87) Messrs. Killick, Nixon & Co. | Do. . . | E. L. . | 1,228 | 10th June 1907. | Do. |
| Do. . | (88) Messrs. Jehángir B. Petit & Co. | Do. . . | E. L. . | 5,296 | 24th June 1907. | Do. |
| Do. . | (89) Mr. V. S. Samba shiva Iyer. | Do. . . | P. L. . | 2,218 | 30th June 1907. | Do. |
| Do. . | (90) Do. do. . | Do. . . | P. L. . | Not stated. | | |
| Do. . | (91) Messrs. D. B. Lam & Co. | Do. . . | P. L. . | 75 | 26th July 1907. | Do. |
| Do. . | (92) Do. do. . | Do. . . | P. L. . | 1,737 | Do. . | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## BOMBAY—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Kanara . | (93) Mr. N. H. Patuck . | Manganese . | P. L. . | 306 | 12th August 1907. | 1 year. |
| Do. . | (94) Messrs. D. B. Lam & Co. | Do. . . | E. L. | 10,136 | 18th August 1907. | Do. |
| Do. . | (95) Messrs. N. Fatehalli & Co. | Do. . . | P. L. | 766 | 16th September 1907. | Do. |
| Do. . | (96) The Hon'ble Sir V. D. Thackersay. | Do. . . | Altered from M. L to P. L. | 3,840 | 18th September1907. | Do. |
| Do. . | (97) Messrs. N. Fatehalli & Co. | Do. . . | P. L. | 140 | 16th September 1907. | Do. |
| Do. . | (98) Do. do. . | Do. . . | P. L. . | 2,451 | Do. . | Do. |
| Do. . | (99) Do. do. . | Do. . . | P. L. . | 2,501 | Do. . | Do. |
| Do. . | (100) Mr. N. H. Patuck | Do. . . | P. L. . | 568 | 12th August 1907. | Do. |
| Do. . | (101) Mr. S. N. Chandabhoy. | Do. . . | P. L. . | 320 | 10th August 1907. | Do. |
| Do. . | (102) The Hon'ble Sir V. D. Thackersay. | Do. . . | P. L. . | 3,991 | 18th September 1907. | Do. |
| Do. . | (103) Mr. S. N. Chandabhoy. | Do. . . | P. L. . | 30 | 10th August 1907. | Do. |
| Do. . | (104) Mr. C. B. Oakley . | Do. . . | P. L. . | 1,809 | 31st October 1907. | Do. |
| Do. . | (105) Mr. N. F. Boyce . | Do. . . | P. L. . | 4,624 | 21st December 1907. | Do. |
| Do. . | (106) Mr. C. P. Boyce . | Do. . . | P. L. . | 385 | 31st October 1907. | Do. |
| Do. . | (107) Messrs. D. B. Lam & Co. | Do. . . | P. L. . | 39 | 21st September 1907. | Do. |
| Do. . | (108) Mr. Madhulal Doogar. | Do. . . | E. L. | 1,596 | 11th November 1907. | Do. |
| Do. . | (109) Mr. Madappa Ganappa Hegde. | Do. . . | E. L. . | 628,547 | 19th November 1907. | Do. |
| Do. . | (110) Mr. D. F. Frizoni . | Do. . . | E. L. . | 2,117 | 1st and 4th November 1907. | Do. |

E L denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## BOMBAY—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Kanara . | (111) Mr. Kaikubad F. Bamji. | Manganese . | P. L. . | 160 | 19th December 1907. | 1 year. |
| Do. . | (112) Mr. S. N. Chandabhoy. | Yellow ochre . | E. L. . | 40 | 20th December 1907. | Do. |
| Panch Mahals | (113) Mr. F. A. H. East, Managing Agent to the Shivrajpur Syndicate of Cory Bros. & Co., Bombay. | Manganese . | M. L. . | 36 | 1st November 1906. | 30 years. |
| Do. . | (114) Do. do . | Do. . . | M. L. | 492 | Do. . | Do. |
| Do. . | (115) Do. do. . | Do. . . | M. L. . | | Do. . | Do. |
| Do. . | (116) Mr. C. J. Demetracopulo. | Do. . . | P. L. . | 640 | 22nd March 1907. | 1 year. |
| Do. . | (117) Do. do. . | Do. . . | P. L. . | 960 | 10th July 1907. | Do. |
| Do. . | (118) Mr. Adarji Muncherji Dalal. | Do. . . | P. L. . | 640 | 8th July 1907. | Do. |
| Do. . | (119) Messrs. Schroder, Smidt & Co. | Do. . . | E. L. . | 2,560 | 30th September 1907. | Do. |
| Do . | (120) Do. do. . | Do. . . | E. L. . | 2,560 | Do . | Do. |
| Do . | (121) Do. do. . | Do. . . | E. L. . | 2,560 | Do. . | Do. |
| Do. . | (122) Do. do. . | Do. . . | E. L. . | 2,560 | Do. . | Do. |
| Do. . | (123) Messrs. Kahn and Kahn & Co. | Do. . . | E. L. . | 1,280 | Do. . | Do. |
| Do. . | (124) Messrs. Schroder, Smidt & Co. | Do. . . | E. L. . | 2,560 | 27th September 1907. | Do. |
| Do. . | (125) Do. do. . | Do. . . | E. L. . | 1,920 | Do. . | Do. |
| Do. . | (126) Mr. Adarji M. Dalal. | Do. . . | E. L. . | 1,840 | 30th September 1907. | Do. |
| Do. . | (127) Mr. Ratanlal Ranchhodlal. | Do. . . | E. L. . | 1,280 | 31st October 1907. | Do. |
| Do. . | (128) Mr. Adarji Muncherji Dalal. | Do. . . | E. L. . | 2,150 | 30th September 1907. | Do. |
| Do. . | (129) Messrs. Kahn, Kahn & Co. | Do. . . | E. L. . | 3,200 | 31st December 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## BOMBAY—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Panch Mahals | (130) Messrs. Jesingbhoy Maganlal & Co. | Manganese | E. L. | Not exceeding 640 acres. | 31st December 1907. | 1 year. |
| Do. | (131) Messrs. Schroder, Smidt & Co. | Do. | E. L. | 2,560 | 31st October 1907. | Do. |
| Do. | (132) Do. do. | Do. | E. L. | 2,560 | Do. | Do. |
| Do. | (133) Do. do. | Do. | E. L. | 2,560 | Do. | Do. |
| Do. | (134) Mr. W. C. Symes | Mica | E. L. | 160 | 30th September 1907. | Do. |
| Do. | (135) Mr. Ismailji Abdul Hussain. | Manganese | E. L. | 640 | 31st October 1907. | Do. |
| Do. | (136) Do. do. | Do. | E. L. | 2,560 | Do. | Do. |
| Do. | (137) Do. do. | Do. | E. L. | | Do. | Do |
| Do. | (138) Messrs. Schroder, Smidt & Co. | Do. | E. L. | 2,560 | Do. | Do. |
| Do. | (139) Do. do. | Do. | E. L. | 3,200 | 13th December 1907. | Do. |
| Do. | (140) Messrs. Turner & Co. | Do. | E. L | 1,440 | 31st October 1907. | Do. |
| Do. | (141) Do do. | Do. | E. L. | 1,280 | Do. | Do. |
| Do. | (142) Do. do. | Do. | E. L. | | Do. | Do. |
| Do. | (143) Do. do. | Do. | E. L. | 2,560 | Do. | Do. |
| Do. | (144) Messrs. Schroder, Smidt & Co. | Do. | E. L. | 3,200 | 13th December 1907. | Do. |
| Do. | (145) Messrs. J. F. Karaka & Co | Do. | E. L. | 1,280 | 30th September 1907. | Do. |
| Do. | (146) Do. do. | Do. | E. L. | 300 | 31st October 1907. | Do. |
| Do. | (147) Do. do. | Do. | E. L. | 800 | 30th September 1907 | Do. |
| Do. | (148) Do. do. | Do. | E. L. | 1,280 | 31st October 1907. | Do. |
| Do. | (149) Do. do. | Do. | E. L. | 1,200 | Do. | Do. |
| Do. | (150) Do do. | Do. | E. L. | 1,020 | Do. | Do. |
| Ratnagiri | (151) Messrs. Shaw, Wallace & Co., Bombay. | Do. | E. L. | 2,560 | 17th May 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## BOMBAY—*concld.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Ratnagiri . | (152) Messrs. Shaw, Wallace & Co., Bombay. | Manganese . | E. L. . | 41,600 | 31st July 1907. | 1 year. |
| Do. . | (153) Do. do. . | Do. . . | E. L. . | 152,320 | Do. . | Do. |
| Do. . | (154) Do. do. . | Do. . . | P. L. | 61 | 14th October 1907. | Do. |

## BURMA.

| | | | | | | |
|---|---|---|---|---|---|---|
| Akyab . | (155) U. Thu Taw U, U. Shwe Min and U. Aung Bau. | Coal . . | M. L. | 500 | 1st October 1907. | 30 years. |
| Amherst . | (156) Foucar & Co . | Antimony . | P. L. | 309·14 | 27th June 1907. | 1 year. |
| Bassein . | (157) Maung Po Mya . | Coal . . | P. L. renewal . | 3,200 | 30th September 1907. | Do. |
| Bhamo . | (158) Lt.-Col. S. G. Radcliff, on behalf of Mr. A. C. Macmillan. | Gold . . | P. L. | Unsurveyed, about 5,760 acres. | 15th February 1907. | Do. |
| Do. . | (159) Do. do. . | Do. . . | P. L. . | 180 | 1st August 1907. | Do. |
| Henzada . | (160) Messrs. Leslie, Crawford and five others. | Coal. . . | P. L. . | 2,560 | 19th April 1907. | Do. |
| Do. . | (161) Mr. Allan Campbell. | Do. . . | P. L. . | 2,560 | 18th December 1907. | Do. |
| Katha . . | (162) Lim Chin Tsong . | Copper . . | P. L. . | 201·50 | 22nd June 1907. | Do. |
| Do. . | (163) Mr. J. A. Manyon | Copper, lead and associated ores. | P. L. . | 2,880 | 17th April 1907. | Do. |
| Do. . | (164) Do. do. . | Coal . . | P. L. . | 1,350·4 | 10th July 1907. | Do. |
| Mandalay . | (165) Mr. C. D. Clarke, on behalf of the Burma Mines Railway and Smelting Co., Ltd. | Iron ore . . | P. L. . | 240 | 8th January 1907. | Do. |
| Do. . | (166) Do. do. . | Do. . . | P. L. . | 68·83 | 1st June 1907. | Do. |
| Do. . | (167) Mr. R. J. Boog . | Silver and lead . | M. L. . | 160 | 1st November 1906. | 10 years. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## BURMA—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Mandalay . | (168) Moola Dawood . | All minerals . | E. L. . | Whole of the Mandalay District. | 23rd September 1907. | 1 year. |
| Mergui . | (169) Mr. A. B. Snow, on behalf of the Burma Development Syndicate, Ltd. | Tin . . . | M. L. . | 1,955·72 | 1st July 1906. | 30 years. |
| Do. . | (170) Mr. Louis Joel for Anglo Continental Gold Syndicate, Ltd. | Do. . . . | P. L. . | 6,400 | 18th March 1907. | 1 year. |
| Do. . | (171) Mr. H. Broadbent for Maliwun Tin Mining Syndicate. | Do. . . . | P. L. . | 3,093·03 | 24th March 1907. | Do. |
| Do. . | (172) Messrs. Summers and Okeden, on behalf of Lt.-Col. K. M. Foss. | Iron-ores . . | E. L. . | 1,941 | 16th September 1907. | Do. |
| Do. . | (173) Messrs. R. S. Giles and E. Higginbotham, Advocates for South Burma Tin Mines, Ltd. | Tin . . . | P. L. renewal . | 307·56 | 23rd September 1907. | For the period ending 18th April 1908. |
| Do. . | (174) Messrs. Kinloch and Eglinton. | Do. . . . | P. L. renewal . | 105·24 | 2nd June 1907. | 1 year. |
| Do. . | (175) Mr. Charles Kitchin. | Do. . . . | P. L. renewal . | 640 | 2nd November 1907. | For the period ending 24th August 1908. |
| Minbu . | (176) Suliman Acha . | Copper and lead | E. L. . | Ngapi Padien Yoma Hill, Pauksat Hill and Sinlangyi jungle. | 11th November 1907. | 1 year. |
| Myingyan . | (177) Messrs. Finlay, Fleming & Co., Agents for the Burma Oil Co., Ltd. | Petroleum . | P. L. . | 3,504 | 4th October 1906. | Do. |
| Do. . | (178) Do. do. . | Do. . . | P. L. . | 85 | 19th January 1907. | Do. |
| Do. . | (179) Do. do. . | Do. . . | P. L. . | 1,280 | 15th September 1907. | Do. |
| Do. . | (180) Do. do. . | Do. . . | P. L. renewal . | 12,853¼ | 1st May 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## BURMA—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Myingyan . | (181) Rangoon Oil Co., Ltd. | Petroleum . | P. L. renewal . | 640 | 10th May 1907. | 1 year. |
| Do. . | (182) Mr. J. W. Parry . | Do. . . | E. L. . | 2,560 | 30th September 1907. | Do. |
| Do. . | (183) Messrs Finlay, Fleming & Co., Agents, Burma Oil Co., Ltd. | Do. . . | P. L. . | 2,560 | 10th July 1907. | Do. |
| Do. . | (184) Do. do. . | Do. . . | P. L. renewal . | 1,280 | 15th September 1907. | Do. |
| Myitkyina . | (185) Burma Gold Dredging Co. | Gold, copper, platinum, etc. | P. L. . | 6,400 | 2nd April 1907. | Do. |
| N. Shan States. | (186) Mr. W. R. Hillier . | Copper and allied metals. | P. L. . | 2,560 | 11th February 1907. | Do. |
| Do. | (187) The Great Eastern Mining Co., Ltd. | Silver, copper, lead and zinc. | M. L. . | 10,240 | 1st January 1907. | 30 years. |
| Do. . | (188) Mr. A. G. Blackwell. | Gold . . | E. L. . | 9,536 | 24th June 1907. | 1 year. |
| Do. . | (189) Mr. R. S. Dickie . | Copper . . | P. L. . | 640 | 23rd April 1907. | Do. |
| Do. . | (190) Mr. F. Eggena . | Silver, lead, antimony and allied minerals. | P. L. . | 3,200 | 12th September 1907. | Do. |
| Do. . | (191) Mr. N. Samwell . | Silver, lead, and associated minerals. | P. L. . | Not exceeding 3,200 acres. | 12th November 1907. | Do. |
| Pakôkku . | (192) Messrs. W. F. Noyce and A. Sarkies. | Petroleum . | P. L. . | 1,920 (Blocks 80, 81 and 82, at Yonangyat.) | 16th January 1907. | Do. |
| Do. . | (193) Maung Po Myo . | Petroleum and coal. | E. L. . | 9,720 | 2nd February 1907. | Do. |
| Do. . | (194) M. Goolam Hussein. | Petroleum . | E. L. . | Whole district except reserved forest. | 26th July 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*concld.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Pakôkku . | (195) Messrs. Finlay, Fleming & Co., Agents, Burma Oil Co., Ltd. | Petroleum . . | P. L. . | 1,920 | 9th October 1907. | 1 y a |
| Do. . | (196) Do. do. . | Do. . . | P. L. . | 640 | Do. . | Do. |
| Do. . | (197) Mr. J. W. Parry . | Petroleum and other minerals. | E. L. . | 1,280 | 14th August 1907. | Do. |
| Ruby Mines . | (198) Mr. A. G. Blackwell, on behalf of the Shweli Gold Dredging and Mining Syndicate, Ltd. | Gold . . . | P. L. . | 80 miles of the Shweli river from Myitson to Inywa. | 31st March 1907. | Do. |
| S. Shan States. | (199) Messrs. H. R. Fagan and C. R. Connel. | Coal . . | P. L. . | 960 | 7th March 1907. | Do. |
| Do. . | (200) Do. do. . | Do. . . . | P. L. . | 320 | Do. . | Do. |
| Do. . | (201) Mr. W. R. Hillier . | Antimony and other ores. | P. L. . | Not stated | 12th June 1907. | Do. |
| Do. . | (202) Mr. A. T. Moore Bennett. | Copper . . | P. L. . | 1,920 | 11th September 1907. | Do. |
| Do. . | (203) Mr. G. M. Hamlyn, on behalf of Mr. W. Bruce Dick. | Minerals and mineral oil. | P. L. . | Not stated | 4th December 1907. | 4 years. |
| Tavoy . | (204) Mr. A. G. Meinhold, Manager, Dickman Bros. & Co. | All minerals . | P. L. . | 1,616 | 12th June 1907. | 1 year. |
| Do. . | (205) Do. do. . | Do. . . | P. L. . | 1,280 | Do. | Do. |
| Thayetmyo . | (206) Messrs. A. S. Jamal Bros. & Co. | Petroleum . | P. L. . | 640 | 14th September 1907. | Do. |
| Toungoo . | (207) Mr. T. F. Francis, Agent for Mr. C. E. Brown. | Silver, lead, and other metals. | P. L. renewal . | 3,200 | 30th April 1907. | Do. |
| Yamethin . | (208) Mr. A. C. Macmillan. | Gold, silver, lead, copper and tin. | P. L. . | 1,280 | 14th November 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## CENTRAL PROVINCES.

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Balaghat . | (209) Mr. Mahammed Sirajuddin Khan, zemindar of Bahela. | All kinds of minerals. | E. L. . | 406 | 4th December 1906. | 1 year. |
| Do. . | (210) Do. do. . | Do. . . | E. L. . | 1,578 | Do. . | Do. |
| Do. . | (211) Rai Saheb Mathura Prasad and Motilal of Chhindwara . . | Do. . . | E. L. . | 1,129 | 6th December 1906. | Do. |
| Do. . | (212) Do. do. . | Do. . . | E. L. . | 344 | Do. . | Do. |
| Do. . | (213) Messrs. Dutt, Burn & Co. of Jubbulpore. | Manganese. . | P. L . | 490 | 9th March 1907. | Do. |
| Do. . | (214) The Central Provinces Prospecting Syndicate, Kamptee. | Do. . . | M. L. . | 58 | 1st February 1907. | 30 years. |
| Do. . | (215) Messrs. Dutt, Burn & Co. of Jubbulpore. | Do. . . | M. L. . | 401 | 1st March 1907. | Do. |
| Do. . | (216) Do. do. . | Do. . . | P. L. . | 48 | 9th March 1907. | 1 year. |
| Do. . | (217) Mr. D. Laxminarayan of Kamptee. | Do. . . | P. L. . | 39 | 20th February 1907. | Do. |
| Do. . | (218) Diwan Bahadur Kasturchand Daga of Kamptee. | Do. . . | P. L. . | 1,089 | 17th March 1907. | Do. |
| Do. | (219) Mr. E. G. Becket of Kamptee. | Do. . . | P. L. . | 598 | 27th March 1907. | Do. |
| Do. | (220) Mr. C. Velu Ayer of Balaghat. | Do. . . | P. L. . | 132 | 9th March 1907. | Do. |
| Do. . | (221) Rai Sahib Mathura Prasad and Motilal of Chhindwara. | Do. . . | E. L. . | 2,499 | 28th January 1907. | Do. |
| Do. . | (222) Mr. Cooverji Bhoja of Calcutta. | Do. . . | E. L. . | 1,260 | 20th February 1907. | Do. |
| Do. . | (223) Mr. M. M. Mullra, Pleader, Balaghat. | Bauxite . . | E. L. . | 8,639 | 4th March 1907. | Do. |
| Do. . | (224) Mr. E. G. Becket . | Manganese . . | P. L. . | 18 | 11th January 1907. | Do. |
| Do. . | (225) Raja Gokuldas of Jubbulpore. | Do. . . | E. L. . | 5,678 | 4th June 1907. | Do. |
| Do. . | (226) Rambilas Murlidhar Marwari of Kamptee. | Do. . . | P. L. . | 43 | 12th June 1907. | Do. |
| Do. . | (227) Mr. M. M. Mullra . | Do. . . | P. L. . | 19 | 19th June 1907. | Do. |
| Do. . | (228) Mr. M. B. Chopra | Do. . . | P. L. . | 41 | 24th June 1907. | Do. |
| Do. . | (229) Messrs. Byramji Pestonji. | Do. . . | E. L. . | 8,565 | 2nd April 1907. | Do. |
| Do. . | (230) Raja Gokuldas of Jubbulpore. | Do. . . | E. L. . | 199 | 4th June 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Balaghat . | (231) Rai Sahib Mathura Prasad and Motilal. | Manganese . . | E. L. . | 2,360 | 8th June 1907. | 1 year. |
| Do. . | (232) Diwan Bahadur Kusturchand Daga of Kamptee. | Do. . . | E. L. . | 44 | 4th June 1907. | Do. |
| Do. . | (233) Messrs. Dutt, Burn & Co. | Manganese, Bauxite and Iron | P. L. . | 1,316 | 8th June 1907. | Do. |
| Do. . | (234) Rai Sahib Mathura Prasad and Motilal. | Manganese . | P. L. . | 57 | Do. . | Do. |
| Do. . | (235) Messrs. Dutt, Burn & Co. | Do. . . | P. L. . | 149 | 20th April 1907. | Do. |
| Do. . | (236) Do. do. . | Do. . . | P. L. . | 244 | 8th June 1907. | Do. |
| Do. . | (237) Lal Behari Narayandas and Ramcharan Shankarlal. | Do. . . | P. L. | 42 | 7th June 1907 . | Do. |
| Do. . | (238) Diwan Bahadur Kasturchand Daga of Kamptee. | Do. . . | P. L. . | 18 | 25th June 1907. | Do. |
| Do. . | (239) Raja Gokuldas Rai Bahadur Ballavdas of Jubbulpore. | Do. . . | E. L. . | 130 | 4th June 1907. | Do. |
| Do. . | (240) R. S. Mathura Prasad and Motilal. | Do. . . | E. L. . | 2,356 | 8th August 1907. | Do. |
| Do. . | (241) The Central Provinces Prospecting Syndicate. | Do. . . | M. L. . | 273 | 25th July 1907. | 30 years. |
| Do. . | (242) Messrs. Dutt, Burn & Co. of Jubbulpore. | Do. . . | P. L. . | 183 | 22nd July 1907. | 1 year. |
| Do. . | (243) Do. do. . | Do. . . | P. L. . | 744 | Do. . | Do. |
| Do. . | (244) Mr. J. Kellerschon of Nagpur. | Do. . . | P. L. . | 1,180 | 24th July 1907. | Do |
| Do. . | (245) Do. do. . | Do. . . | P. L. . | 166 | Do. | Do. |
| Do. . | (246) Mr. C. Vaylu, Balaghat. | Do. . . | P. L. . | 37 | 27th July 1907. | Do. |
| Do. . | (247) Diwan Bahadur Kasturchand Daga of Kamptee. | Do. . . | P. L. . | 37 | 27th August 1907. | Do. |
| Do. . | (248) Do. do. . | Do. . . | P. L. . | 6 | 26th August 1907. | Do. |
| Do. . | (249) Mr. M. B. Chopra of Jubbulpore. | Mica . . | P. L. . | 607 | 20th August 1907. | Do. |
| Do. . | (250) Mr. Bhimji Kachi, Balaghat. | Manganese . . | P. L. . | 320 | 7th August 1907. | Do. |
| Do. . | (251) Mr. M. M. Mullra, Pleader. | Do. . . | P. L. . | 443 | 24th July 1907. | Do. |
| Do. . | (252) Do. do. . | Do. . . | M. L. . | 19 | 6th September 1907. | 30 years. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Balaghat . | (253) Mr. Heralal Sukul of Kamptee. | Manganese . | P. L. . | 78 | 25th July 1907. | 1 year. |
| Do. . | (254) Mr. Bapuji Vishwanath Gandhi. | Do. . . | P. L. . | 404 | 6th September 1907. | Do. |
| Do. . | (255) Rai Sahib Mathura Prasad and Motilal of Chhindwara. | Do. . . | P. L. . | 10 | 24th July 1907. | Do. |
| Do. . | (256) Mr. M. B. Chopra of Jubbulpore. | Do. . . | P. L. . | 96 | 30th September 1907. | Do. |
| Do. . | (257) Mr. Heralal Sukul, Pleader, of Kamptee. | Do. . . | P. L. . | 26 | 20th August 1907. | Do. |
| Do. . | (258) Mr. J. Kellerschon of Nagpur. | Do. . . | E. L. . | 934 | 24th July 1907. | Do. |
| Do. . | (259) Do. do. . | Do. . . | E. L. . | 391 | Do. . | Do. |
| Do. . | (260) Mr. Byramji Pestonji of Raipur. | Do. . . | E. L. . | 112 | 22nd July 1907. | Do. |
| Do. . | (261) Do. do. . | Do. . . | E. L. . | 27 | 16th August 1907. | Do. |
| Do. . | (262) Mr. M. B. Chopra, Jubbulpore. | Do. . . | E. L. . | 7,201 | 30th September 1907. | Do. |
| Do. . | (263) Mr. S. O. Holmes, Engineer, Balaghat. | Do. . . | E. L. . | 3,927 | Do. . | Do. |
| Do. . | (264) Do. do. . | Do. . . | E. L. . | 146 | Do. . | Do. |
| Do. . | (265) Rai Sahib Mathura Prasad and Motilal. | Mica corundum and dolomite. | P. L. . | 11 | Do. . | Do. |
| Do. . | (266) Messrs. Dutt, Burn & Co. of Jubbulpore | Manganese . | P. L. . | 1,152 | 2nd December 1907 | Do. |
| Do. . | (267) Rai Sahib Mathura Prasad and Motilal of Chhindwara . . | Do. . . | P. L. . | 253 | Do. . | Do. |
| Do. . | (268) Do. do. . | Do. . . | P. L. . | 28 | Do. | Do. |
| Do. . | (270) Do. do. . | Do. . . | P. L. . | 202 | Do. | Do. |
| Do. . | (271) Messrs. Dutt, Burn & Co. of Jubbulpore . | Do. . . | P. L. . | 454 | Do. | Do. |
| Do. . | (272) Rai Sahib Mathura Prasad and Motilal of Chhindwara . . | Do. . . | P. L. . | 91 | Do. | Do. |
| Do. . | (273) Messrs. Dutt, Burn & Co. of Jubbulpur. | Do. . . | P. L. . | 224 | Do | Do. |
| Do. . | (274) Do. do. . | Do. . . | P. L. . | 544 | 8th October 1907. | Do. |
| Do. . | (275) Do. do. . | Do. . . | M. L. . | 169 | 28th October 1907. | 30 years. |
| Do. . | (276) Mr. Rambilas Murlidhar Marwari of Kamptee. | Do. . . | P. L. . | 2 | 7th October 1907. | 1 year. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Balaghat . | (277) Lala B. Sitaram of Nagpur. | Manganese . . | E. L. . | 2,682 | 12th October 1907. | 1 year. |
| Do. . | (278) Do. do. . | Do. . . | E. L. . | 511 | Do. . | Do. |
| Do. . | (279) Mr. D. Laxminarayan of Kamptee. | Do. . . | P. L. . | 24 | 2nd November 1907. | Do. |
| Do. . | (280) Lala B. Sitaram of Nagpur. | Do. . . | P. L. . | 309 | 16th December 1907. | Do. |
| Do. . | (281) Mr. R. H. Richardson of Kamptee. | Do. . . | P. L. . | 32 | 22nd October 1907. | Do. |
| Do. . | (282) Mr. Rambilas Murlidhar Marwari of Kamptee. | Do. . . | P. L. . | 33 | 12th October 1907. | Do. |
| Do. . | (283) Messrs. Dutt, Burn & Co. of Jubbulpore. | Do. . . | P. L. | 64 | 8th October 1907. | Do. |
| Do. . | (284) Diwan Bahadur Kasturchand Daga of Kamptee. | Do. . . | P. L. . | 17 | 19th December 1907. | Do. |
| Do. . | (285) Mr. Byramji Pestonji of Raipur. | Do. . . | P. L. . | 202 | 30th November 1907. | Do. |
| Do. . | (286) Lala Mohan Lal Kalar, Nagpur. | Do. . . | E. L. . | 1,323 | 8th October 1907. | Do. |
| Do. . | (287) Lala Ganesh Prasad and Janki Prasad, Kamptee. | Do. . . | E. L. . | 1,734 | 5th October 1907. | Do. |
| Do. . | (288) Do. do. . | Do. . . | E. L. . | 1,608 | Do. | Do. |
| Do. . | (289) Do. do. . | Do. . | E. L. . | 915 | Do. | Do. |
| Do. . | (290) Mr. Byramji Pestonji of Raipur. | Do. . . | E. L. . | 5,743 | 30th November 1907. | Do. |
| Do. . | (291) Do. do. . | Do. . . | E. L. . | 5,437 | Do. | Do. |
| Betul . | (292) Mr. P. E. Cameron | Coal . . . | E. L. . | 9,109 | 19th December 1907. | Do. |
| Bhandara . | (293) Central Provinces Prospecting Syndicate, Kamptee. | Manganese . . | M. L. . | 507 | 25th February 1907. | 30 years. |
| Do. . | (294) The Central India Mining Company, Limited, Kamptee. | Do. . . | P. L. . | 425 | 15th February 1907. | 1 year. |
| Do. . | (295) Mr. D. Laxminarayan. | Do. . . | P. L. . | 270 | 11th March 1907. | Do. |
| Do. . | (296) The Central India Mining Company, Limited. | Do. . . | P. L. . | 519 | 15th February 1907. | Do. |
| Do. . | (297) Diwan Bahadur Kasturchand Daga of Kamptee. | Do. . . | P. L. . | 455 | 4th June 1907. | Do. |
| Do. . | (298) Rai Sahib Mathura Prasad and Motilal. | Mica . . . | P. L. | 57 | 8th June 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Bhandara . | (299) Dewan Bahadur Kasturchand Daga. | Manganese . . | P. L. . | 842 | 15th May 1907. | 1 year. |
| Do. . | (300) Rambilas Murlidhar Marwari of Kamptee. | Do. . . | P. L. . | 143 | 1st June 1907. | Do. |
| Do. . | (301) Do. do. . | Do. . . | P. L. . | 291 | 3rd June 1907. | Do. |
| Do. . | (302) Mr. G. M. Prichard | Do. . . | E. L. . | 592 | 4th June 1907. | Do. |
| Do. . | (303) Central India Mining Company. | Do. . . | P. L. . | 281 | 15th May 1907. | Do. |
| Do. . | (304) Mr. Byramji Pestonji of Raipur. | Do. . . | E. L. . | 110 | 29th June 1907. | Do. |
| Do. . | (305) Do. do. . | Do. . . | E. L. . | Not furnished | Do. | Do. |
| Do. . | (306) Messrs. Ratanchand Kesrichand Chullany and Sons. | Asbestos . . | M. L. . | 42 | 8th August 1907. | 30 years. |
| Do. . | (307) Do. do. . | Do. . . | P. L. | 1,300 | 15th September 1907. | 1 year. |
| Do. . | (308) Mr. R. S. Richardson. | Manganese . . | P. L. . | 260 | 1st July 1907. | 1 year. |
| Do. . | (309) Central India Mining Company. | Do. . . | M. L. . | 66 | 25th August 1907. | 30 years. |
| Do. . | (310) Mr. Cooverji Bhoja of Calcutta. | Manganese, iron-ore and galena. | P. L. . | 134 | 29th August 1907. | 1 year. |
| Do. . | (311) Rai Sahib Mathura Prasad and Motilal of Chhindwara. | Manganese . . | P. L. . | 295 | Do. | Do. |
| Do. . | (312) Dewan Bahadur Kasturchand Daga of Kamptee. | Do. . . | P. L. . | 1,476 | Do. | Do. |
| Do. . | (313) Mr. Madhulal Doogar of Calcutta. | Do. . . | P. L. . | 50 | 4th July 1907. | Do. |
| Do. . | (314) Mr. D. Laxminarayan of Kamptee. | Do. . . | P. L. . | 2,976 | 7th September 1907. | Do. |
| Do. . | (315) Messrs. Lal Behari Narayandas and Ramcharan Shankerlal of Kamptee. | Do. . . | P. L. . | 35 | 29th August 1907. | Do. |
| Do. . | (316) Mr. Brickbhandas Jagannath Sarkar of Nagpur. | Do. . . | P. L. . | 55 | 29th August 1907. | Do. |
| Do. . | (317) Messrs. Lal Behari Narayandas and Ramcharan Shankerlal of Kamptee. | Iron-ore . . | P. L. . | 207 | Do. . | Do. |
| Do. . | (318) Mr. Brickbhandas Jagannath Sarkar of Nagpur. | Manganese . . | P. L. . | 8 | 4th June 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Bhandara . | (319) Mr. Medhulal Doogar of Calcutta. | Manganese . | P. L. . | 171 | 29th August 1907. | 1 year. |
| Do. . | (320) Do. do. . | Do. . . | P. L. . | 997 | Do. . | Do. |
| Do. . | (321) Messrs. Cursetji & Co. of Kamptee. | Do. . . | E. L. . | 83 | 3rd August 1907. | Do. |
| Do. . | (322) Messrs. Lal Behari Narayandas and Ramcharan Shankerlal of Kamptee. | Do. . . | P. L. . | 140 | 7th September 1907. | Do. |
| Do. . | (323) Mr. J. Kellerschon of Nagpur. | Do. . . | P. L. | 319 | 29th August 1907. | Do. |
| Do. . | (324) Messrs. Lal Behari Narayandas and Ramcharan Shankerlal of Kamptee. | Do. . . | P. L. . | 98 | Do. . | Do. |
| Do. . | (325) Mr. Hiralal Sukul | Do. . . | P. L. . | 157 | 25th September 1907. | Do. |
| Do. .. | (326) Do. do. . | Do. . . | P. L. . | 104 | 7th August . 1907 | Do. |
| Do. . | (327) Mr. R. H. Richardson of Kamptee. | Do. . . | P. L. . | 249 | 1st July 1907. | Do. |
| Do. . | (328) The Hon'ble Gangadhar Rao Chitnavis of Nagpur. | Do. . . | P. L. . | 27 | 25th September 1907. | Do. |
| Do. . | (329) Messrs. Cursetji & Co. of Nagpur. | Do. . . | E. L. . | 64 | 3rd August 1907. | Do. |
| Do. . | (330) Do. do. . | Do. . . | P. L. | 34 | 29th August 1907. | Do. |
| Do. . | (331) Mr. R. H. Richardson of Kamptee. | Do. . . | P. L. . | 156 | 1st July 1907. | Do. |
| Do. . | (332) Messrs. Burjorji Bezonji Bahmansha Faujdar Bros. of Nagpur. | Do. . . | P. L. . | 20 | 30th September 1907. | Do. |
| Do. . | (333) Mr. E. Nagannah Naidu. | Do. . . | P. L. . | 115 | 29th August 1907. | Do. |
| Do. . | (334) The Central India Mining Company, Limited. | Do. . . | P. L. . | 214 | 25th September 1907. | Do. |
| Do. . | (335) Do. do. . | Do. . . | P. L. . | 82 | Do. . | Do. |
| Do. . | (336) Do. do. . | Do. . . | P. L. . | 67 | Do. | Do. |
| Do. . | (337) Do. do. . | Do. . . | P. L. . | 180 | Do. . | Do. |
| Do. . | (338) Messrs. Burjorji Bezonji Bahmansha Faujdar Bros. of Nagpur. | Do. . . | P. L. . | 416 | 30th September 1907. | Do. |
| Do. . | (339) Mr. Byramji D. Dungaji of Kamptee. | Do. . . | P. L. . | 4 | Do. . | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Bhandara . | (340) Messrs. Byramji Pestonji of Raipur. | Manganese . | E. L. . | 109 | 29th June 1907. | 1 year. |
| Do. . | (341) Do. do. . | Do. . . | E. L. . | 2,132 | Do. . | Do. |
| Do. . | (342) Mr. Byramji Pestonji. | Do. . . | E. L. . | 1,238 | 3rd August 1907. | Do. |
| Do. . | (343) Do. do. . | Do. . . | E. L. . | 2,125 | 25th September 1907. | Do. |
| Do. . | (344) The Central India Mining Co. | Mica, corundum and dolomite. | P. L. . | 475 | Do. . | Do. |
| Do. . | (345) Mr. Lalbehari Narayandas. | Do. . . | P. L. . | 38 | 7th September 1907. | Do. |
| Do. . | (346) Rai Sahib Mathura Prasad and Motilal of Chhindwara. | Manganese . . | P. L. . | 97 | 26th November 1907. | Do. |
| Do. . | (347) Do. do. . | Do. . | P. L. . | 99 | 6th December 1907. | Do. |
| Do. . | (348) Do. do. . | Do. . . | P. L. . | 339 | 26th November 1907. | Do. |
| Do. . | (349) Do. do. . | Do. . . | P. L. . | 47 | 26th November 1907. | Do. |
| Do. . | (350) Do. do. . | Do. . . | P. L. . | 61 | Do. . | Do. |
| Do. . | (351) Mr. Byramji Pestonji of Raipur. | Do. . . | P. L. . | 1,075 | 20th December 1907. | Do. |
| Do. . | (352) Mr. Heralal Sukul of Kamptee. | Do. . . | P. L. . | 650 | 26th November 1907. | Do. |
| Do. . | (353) Messss. Cursetji & Co. | Do. . . | P. L. . | 64 | 4th October 1907. | Do. |
| Do. . | (354) Do. do. . | Do. . . | E. L. . | 7 | 9th December 1907. | Do. |
| Do. . | (355) Mr. Horalal Sukul, Pleader, of Kamptee. | Do. . . | P. L. . | 0·68 | 4th October 1907. | Do. |
| Do. . | (356) Do. do. . | Do. . . | P. L. . | 21 | Do. . | Do. |
| Do. . | (357) Messrs. Cursetji & Co. of Kamptee. | Do. . . | P. L. . | 4 | 6th December 1907. | Do. |
| Do. . | (358) Do. do. . | Do. . . | P. L. . | 20 | 4th October 1907. | Do. |
| Do. . | (359) Mr. J. J. Velloz of Nagpur. | Do. . . | P. L. . | 142 | 5th October 1907. | Do. |
| Do. . | (360) Babu E. Nagannah Naidu, Bilaspur. | Do. . . | P. L. . | 39 | 6th December 1907. | Do. |
| Bilaspur . | (361) Mr. Byramji Pestonji of Raipur. | Do. . . | E. L. . | 1,393 | 14th August 1907. | Do. |
| Chhindwara . | (362) Rai Sahib Mathura Prasad and Motilal. | Do. . . | M. L. . | 63 | 18th January 1907. | 30 years. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Chhindwara . | (363) Rai Sahib Mathura Prasad and Motilal | Manganese . | E. L. . | Not reported | 29th April 1907. | 1 year. |
| Do. . | (364) Mr. J. J. Velloz . | Do. . . | E. L. . | 356 | 23rd May 1907. | Do. |
| Do. . | (365) Cursetji & Co. . | Do. . . | E. L. . | 87 | 31st May 1907. | Up to 30th May 1908. |
| Do. . | (366) Khan Bahadur Ali Raza Khan. | Do. . . | E. L. . | Not reported | Do. . | Do. |
| Do. . | (367) Messrs. Vishwanath Rao Salpekar and Kartarbux. | Do. . . | P. L. . | 655 | 18th July 1907. | 1 year. |
| Do. . | (368) Do. do. . | Do. . . | P. L. . | 655 | Do. . | Do. |
| Do. . | (369) Seth Ramlal and Seth Sukhlal. | Do. . . | P. L. . | 25 | 12th August 1907. | Do. |
| Do. . | (370) Do. do. . | Do. . . | P. L. . | 258 | 12th September 1907. | Do. |
| Do. . | (371) Messrs. V. D. Salpekar and Kartarbux. | Do. . . | P. L. . | 268 | 1st August 1907. | Do. |
| Do. . | (372) Do. do. . | Do. . . | P. L. . | 168 | Do. . | Do. |
| Do. . | (373) Mr. J. J. Velloz of Nagpur. | Do. . . | P. L. . | 253 | 20th September 1907. | Do. |
| Do. . | (374) Messrs. V. D. Salpekar and Kartarbux. | Do. . . | P. L. . | 99 | 18th July 1907. | Do. |
| Do. . | (375) Do. do. . | Do. . . | P. L. . | 92 | Do. . | Do. |
| Do. . | (376) Do. do. | Do. . . | P. L. . | 98 | 20th September 1907. | Do. |
| Do. . | (377) Khan Bahadur Ali Raza Khan. | Copper . . | P. L. . | 52 | 20th September 1907. | Do |
| Do. | (378) Messrs. V. D. Salpekar and Kartarbux. | Manganese . | P. L. . | 72 | 22nd July 1907. | Do. |
| Do. . | (379) Do. do. | Do. | P. L. . | 114 | 20th September 1907. | Do. |
| Do. . | (380) Khan Bahadur Ali Raza Khan. | Do | P. L. . | 96 | Do. . | Do. |
| Do. | (381) Do. do. | Do. . . | P. L. . | 463 | 10th September 1907. | Do. |
| Do. . | (382) Messrs. V. D. Salpekar and Kartarbux. | Do. . . | P. L. . | 37 | 20th September 1907. | Do. |
| Do. . | (383) Mr. J. J. Velloz . | Do. . . | E. L. . | 256 | Do. . | Do. |
| Do. . | (384) Seth Ramlal and Sukhlal. | Do. | E. L. . | 416 | 9th August 1907. | Do. |
| Do. . | (385) H. Verma and K. Lal. | Do. . . | E. L. . | Not reported | 21st August 1907. | Do. |
| Do. . | (386) Messrs. V. D. Salpekar and Kartarbux. | Do. . . | P. L. . | 89 | 8th October 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nagpur . | (426) Messrs. Ratanchand Keshrichand Chullany & Co. | Manganese . | P. L. . | 101 | 27th May 1907. | 1 year. |
| Do. . | (427) Mr. D. Laxminarayan of Kamptee. | Do. . . | P. L. . | 125 | 24th April 1907. | Do. |
| Do. . | (428) Do. do. . | Do. . . | P. L. . | 290 | Do. . | Do. |
| Do. . | (429) Messrs. B. Bezonji Bahamanshaw Fouzdar & Bros. | Do. . . | E. L. . | Not reported | 27th May 1907. | Do. |
| Do. . | (430) Messrs. Lal Behari Narayandas and Ramcharan Shanker Lal of Kamptee. | Do. . . | P. L. . | 46 | 21st August 1907. | Do. |
| Do. . | (431) The Central Provinces Prospecting Syndicate. | Do. . . | M. L. . | 10 | 3rd September 1907. | 30 years |
| Do. . | (432) Do. do. | Do. . . | M. L. . | 15 | Do. . | Do. |
| Do. . | (433) Messrs. Lal Behari Naryandas and Ramcharan Shanker Lal of Kamptee. | Do. . . | P. L. . | 83 | 5th August 1907. | 1 year. |
| Do. . | (434) The Central Provinces Prospecting Syndicate. | Do. . . | M. L. . | 17 | 3rd September 1907. | 30 years. |
| Do. . | (435) Mr. D. Laxminarayan of Kamptee. | Do. . . | P. L. . | 168 | 30th September 1907. | 1 year. |
| Do. . | (436) Messrs. Burjorji Bezonji Bahamanshaw Fouzdar & Bros. of Nagpur. | Do. . . | P. L. . | 100 | 8th July 1907. | Do. |
| Do. . | (437) Messrs. Cursetji & Co. of Kamptee. | Do. . . | P. L. . | 320 | 12th August 1907. | Do. |
| Do. . | (438) Mr. D. Laxminarayan of Kamptee. | Do. . . | P. L. . | 433 | 3rd September 1907. | Do. |
| Do. . | (439) Lala B. Sitaram of Nagpur. | Do. . . | P. L. . | 170 | 26th August 1907. | Do. |
| Do. . | (440) Mr. Cooverji Bhoja | Do. . . | E. L. . | 785 | 17th August 1907. | Do. |
| Do. . | Do. do. . | Do. . . | E. L. . | 71 | 9th September 1907. | Do. |
| Do. . | (441) Mr. J. J. Velloz . | Do. . . | E. L. . | 224 | 12th August 1907. | Do. |
| Do. . | (442) Mr. S. O. Holmes . | Do. . . | E. L. . | Whole village | 19th September 1907. | Do. |
| Do. . | (443) The Central India Mining Co., Ltd. | Do. . . | M. L. . | 34 | 29th November 1907. | 30 years. |
| Do. . | (444) The Indian Manganese Co., Ltd. | Do. . . | P. L. . | 80 | 14th October 1907. | 1 year. |
| Do. . | (445) Mr. B. V. Kaoray of Wardha. | Do. . . | P. L . | 310 | 18th October 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## CENTRAL PROVINCES—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nagpur . | (446) Messrs. Burjorji Bezonji Bahamanshaw Foujdar & Bros. of Nagpur. | Manganese . . | P. L. . | 37 | 22nd October 1907. | 1 year. |
| Do. . | (447) Messrs. Cursetji & Co. of Kamptee. | Do. . . | P. L. . | 60 | 8th October 1907. | Do. |
| Do. . | (448) Lala B. Sitaram of Nagpur. | Do. . . | P. L. . | 160 | 18th October 1907. | Do. |
| Do. . | (449) Messrs. Jessop & Co. of Calcutta. | Do. . . | P. L. | 288 | 16th December 1907. | Do. |
| Do. . | (450) Messrs. Cursetji & Co. of Kamptee. | Do. . . | P. L. . | 111 | 8th October 1907. | Do. |
| Do. . | (451) Rajaram Sitaram Dixit of Nagpur. | Do. . . | P. L. . | 40 | 2nd December 1907. | Do. |
| Do. . | (452) Mr. J. J. Velloz of Nagpur. | Do. . . | P. L. . | 224 | 23rd December 1907. | Do. |
| Do. . | (453) Mr. Shamji Madhoji of Kamptee. | Do. . . | P. L. . | 672 | 13th November 1907. | Do. |
| Do. . | (454) Messrs. Ghoredutt and D'Costa. | Do. . . | E. L. . | 72 | 19th November 1907. | Do. |
| Do. . | (455) Mr. Byramji Pestonji of Raipur. | Do. . . | E. L. . | Not reported | 11th October 1907. | Do. |
| Do. . | (456) Mr. S. O. Holmes . | Manganese, iron, tin, copper, bismuth, wolfram and molybdenum. | E. L. . | Do. | 20th November 1907. | Do. |
| Do. . | (457) Do. do. . | Do. . . | E. L. . | Do. | Do. | Do. |
| Do. . | (458) Messrs. Kassambhoy, Ramji & Co. | Manganese . . | E. L. . | 76 | 11th October 1907. | Do. |
| Do. . | (459) Do. do. | Do. . . | E. L. . | 92 | 18th October 1907. | Do. |
| Do. . | (460) The Jubbulpore Prospecting Syndicate. | Do. . . | E. L. . | 209 | 18th November 1907. | Do. |
| Narsinghpur | (461) Mr. H. Mitra. . | Gold, silver, copper, lead, barytes, tin, zinc, arsenic, iron pyrites | P. L. . | 76 | 21st May 1907. | Do. |
| Do. . | (462) Raja Gokuldas . | All minerals . | E. L. . . | Not reported | 5th August 1907. | Do. |
| augor . | (463) Messrs. Kaliprasanna Mukherji and Bhagwandas Siwaya, Pleaders, Saugor. | Mica, corundum and dolomite. | E. L. . | 8,503 | 29th September 1907. | Do. |
| Do. . | (464) Do. do. | All minerals . | P. L. . | 90 | 18th November 1907. | Do. |
| ›oni . . | (465) Messrs. Lal Behari Narayandas and Ramcharan Shankerlal. | Manganese . . | P. L. . | 63 | 26th June 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## CENTRAL PROVINCES—*concld.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Seoni . . | (466) Gowri Shankar and Bakhtawar Singh. | Manganese . | P. L. . | 946 | 7th June 1907. | 1 year. |
| Do. . | (467) Messrs. Gaurishanker and Bakhtawar Singh. | Do. . . | P. L. . | 946 | 24th September 1907. | Do. |
| Do. . . | (468) Byramji Pestonji of Raipur. | Do. . . | P. L. . | 60 | 30th September 1907. | Do. |
| Do. . . | (469) Byramji D. Dungaji of Kamptee. | Do. . . | P. L. . | 7·44 | Do. . | Do. |
| Do. . . | (470) Burjorji Bezonji Bahmansha Fouzdar and Bros., Nagpur. | Do. . . | P. L. . | 300 | Do. | Do. |
| Do. . . | (471) Mr. Gouri Shanker and Dadu Bakhtawar Singh, Seoni. | Do. . . | P. L. . | 148 | 24th September 1907. | Do. |
| Do. . . | (472) Dadu Vishwanath Singh of Seoni. | Do. . . | P. L. . | 80 | Do. . | Do. |
| Do. . . | (473) Do. do. . | Do. . . | P. L. . | 74 | Do. . | Do. |
| Do . . | (474) Do. do. . | Do. . . | P. L. . | 302 | Do. . | Do. |
| Do. . . | (475) Mr. Rambilas Murlidhar of Kamptee. | Do. . . | P. L. . | 173 | 28th December 1907. | Do. |
| Do. . . | (476) Mr. Byromji Pestonji of Raipur. | Do. . . | E. L. . | Forest Block No. 20 Korai Range. | 15th December 1907. | Do. |
| Do. . . | (477) Do. do. . | Do. . . | E. L. . | Forest Block No. 21 in the Piparia Range. | Do. | Do. |
| Do. . . | (478) Mr. Dadu Vishwanath Singh of Seoni. | Do. . . | P. L. . | 457 | 1st November 1907. | Do. |
| Do. . . | (479) Do. Do. | Do. . . | P. L. . | 864 | Do. . | Do. |
| Do. . . | (480) Mr. Rambilas Murlidhar of Kamptee. | Do. . . | P. L. . | 30 | 11th November 1907. | Do. |
| Do. . . | (481) Rai Bahadur Lala Onkardas of Seoni. | Do. . . | P. L. . | 173 | 28th December 1907. | Do. |
| Do. . . | (482) Mr. Dadu Vishwanath Singh of Seoni. | Do. . . | P. L. . | 166 | 20th November 1907. | Do. |
| Do. . . | (483) Do. do. | Do. . . | P. L. . | 59 | Do. . | Do. |
| Do. . . | (484) Mr. Byramji Pestonji of Raipur. | Do. . . | E. L. . | Not reported. | 15th December 1907. | Do. |
| Yeotmal . | (485) Messrs. Parry & Co. | Coal . . . . | P. L. . | 14,050·35 | For three licenses 1st February 1907 and for one license 3rd June 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## EASTERN BENGAL AND ASSAM.

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Chittagong . | (486) Messrs. Turner Morrison & Co. | Coal, oil, gold, etc. | P. L. . | 2,675·20 | 10th July 1907. | 1 year. |
| Lakhimpur . | (487) Assam Oil Co., Ltd., of Digboi. | Oil and its allied products. | P. L. . | 59,424 | 1st February 1907. | Do. |
| Do. . | (488) Babu Nanda Kisor Beria of Dibrugarh. | Coal . . . | P. L. . | 9,516·80 | 1st March 1907. | Do. |

## MADRAS.

| | | | | | | |
|---|---|---|---|---|---|---|
| Anantapur . | (489) Mr. Charles Aubert | Diamonds . . | P. L. . | 20·37 | The issue of a license was sanctioned in November 1907. Mr. Aubert since requested that it may be issued in the name of Mr. M. Tardival. He has been instructed to put in a formal application. | |
| Bellary . | (490) Mr. A. Ghosh for Mr. Jambon. | Manganese . . | P. L. . | 18·68 | 2nd January 1907. | 1 year. |
| Do. . | (491) Mr. A. Ghosh . | Metalliferous minerals and precious stones. | E. L. . | 4,236 | 15th July 1907. | Do. |
| Do. . | (492) M. Ramachendra Rao. | Manganese . . | P. L. . | 36 | 23rd November 1907. | Do. |
| Do. . | (493) Mr. F. W. E. Dunn | Do. | E. L. . | 68·41 | 8th January 1908. | Do. |
| Coimbatore . | (494) Govindjee Odojee Salt. | Corundum . | M. L. in patta land. | 5·88 | 4th July 1907. | 2 years. |
| Cuddapah . | (495) Mr. C. W. Schemburg. | All minerals | E. L. . | 7,680 | 21st January 1907. | 1 year. |
| Do. . | (496) Mr. T. B. Kanthária. | Lead and copper | E. L. . | Two taluks | 4th May 1907 | Do. |
| Do. . | (497) Mr. A. Raghavalu Nayudu. | Mica . . . | E. L. . | In the four taluks viz., Cuddapah, Madanapalle, Vayalpad and Kadiri taluks. | 16th April 1907. | Do. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## MADRAS—*contd.*

| District. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Cuddapah . | (498) Mr. J. Krishnaswami Nayud . | Mica . . . | E. L. . | In the four taluks, *viz.*, Madanpalle, Vayalpad, Pullampet, and Kadiri taluks. | 5th May 1907 | 1 year. |
| Godavari . | (499) Mr. S. D. Ware . | Iron, manganese and graphite. | P. L. . | 279·96 | 23rd July 1907. | Do. |
| Guntur . | (500) Mr. S. Craushaw, Manager, Madras Manganese Co. | Copper . . | P. L. . | 12·95 | 4th July 1907. | Do. |
| Do. . | (501) Do do. | Do. . . . | P. L. . | 2·93 | Do. . | Do. |
| Do. . | (502) Do. do. | Precious stones . | P. L. . | 13·84 | 11th June 1907. | Do. |
| Do. . | (503) Mr. W. Gaye . | Copper, lead, silver and gold. | P. L. . | 400 | The applicant requested in a subsequent letter that the license applied for might be kept in abeyance for the present. | |
| Kurnool . | (504) Mr. Charles Aubert, Consul for Uruguay and Vice Consul for Portugal. | Metalliferous minerals and precious stones. | E. L. . | 432 | 30th January 1907. | 1 year. |
| Do. . | (505) Mr. T. B. Kantheria | Lead and copper . | E. L. . | about 76,800 | 4th May 1907 | Do. |
| Do. . | (506) Messrs. Dymes & Co. | Manganese, gold, copper, and precious stones. | E. L. . | 1,239,600 | 2[illegible]th [illegible]ugus[illegible] 1907. | Do. |
| Do. . | (507) Mr. C. N. Bhose . | All minerals . | E. L. . | 70,640 | 4th October 1907. | Do. |
| Malabar . | (508) Mr. A. O. Dreshler | Manganese . . | E. L. . | 512,000 | 11th July 1907. | Do. |
| Do. . | (509) Mr. F. W. F. Fletcher. | Gold . . . | P. L. . | Not ascertainable. | 2nd October 1907. | Do. |
| Nellore . | (510) Mr. L. Chenga Reddi. | Mica . . . | P. L. . | 18·85 | 8th January 1907. | Do. |
| Do. . | (511) Mr. R. V. Kuppuswami Aiyar. | Do. . . . | P. L. . | 16·60 | 27th March 1907. | Do. |
| Do. . | (512) Mr. R. Rangasami Rao. | Do. . . . | P. L. . | 19 | 23rd January 1907. | Do. |
| Do. . | (513) Muhammad Asa-ud-din Ahmad Sahib. | Do. . . . | P. L. . | 12·54 | 7th March 1907. | Do. |
| Do. . | (514) D. Pechala Nayudu | Do. . . . | E. L. . | Not fixed . | 21st March 1907. | Do. |
| Do. . | (515) R. V. Rangaswami Rao. | Do. . . . | M. L. . | 20 | 13th October 1906. | 3 years. |

E. L., denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## MADRAS.—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nellore . | (516) Haji Muhammad Badsha Sahib & Co. | Mica . . . . | M. L. extension. | 188·85 | 4th December 1906. | 30 years. |
| Do. . . | (517) P. Ramaraghava Reddi. | Do. . . . | Mining in patta land. | 519·44 | 4th September 1906. | 20 years. |
| Do. . . | (518) V. Annaji Rao . | Do. . . . | M. L. . | 83·58 | 3rd October 1906. | 30 years. |
| Do. . | (519) R. Rangaswami Rao. | Do. . . . | P. L. . | 71·10 | 27th February 1907. | 1 year. |
| Do. . . | (520) T. Sitarami Reddi | Do. . . . | P. L. . | 17·11 | 18th January 1907. | Do. |
| Do. . . | (521) T. Venkata Reddi . | Do. . . . | P. L. . | 19·40 | 22nd January 1907. | Do. |
| Do. . . | (522) L. Chenga Reddi . | Do. . . . | P. L. . | 18·80 | 27th February 1907. | Do. |
| Do. . . | (523) R. V. Kuppuswami Aiyar. | Do. . . . | P. L. . | 18·85 | 14th February 1907. | Do. |
| Do. . . | (524) R. Lakshminarasa Reddi. | Do. . . . | P. L. . | 20 | 27th March 1907. | Do. |
| Do. . . | (525) J. Pattabirami Reddi. | Do. . . . | M. L. . | 44·95 | 29th December 1906. | 3 years. |
| Do. . . | (526) T. Venkata Reddi . | Do. . . . | M. L. . | 64·78 | 4th August 1906. | 30 years. |
| Do. . . | (527) R. Lakshminarasa Reddi. | Do. . . . | M. L. extension. | 133·79 | 14th November 1906. | Do. |
| Do. . . | (528) Muhammad Fasi-ud-din. | Do. . . . | M. L. . | 219 | 12th February 1907. | Do. |
| Do. . . | (529) S. Venkatasubbiah | Do. . . . | M. L. extension. | 153·61 | 18th January 1907. | 3 years. |
| Do. . . | (530) P. Chenchuramayya | Do. . . . | M. L. . | [ 58·22 ] | 3rd December 1906. | 10 years. |
| Do. . . | (531) T. Venkata Reddi . | Do. . . . | M. L. . | 163·60 | 9th December 1906. | 3 years. |
| Do. . . | (532) Haji Muhammad Badsha Sahib & Co. | Do. . . . | M. L. extension. | 48·30 | 15th March 1907. | 30 years. |
| Do. . . | (533) L. Chenga Reddi . | Do. . . . | M. L. . | 3·05 | 28th November 1906. | 3 years. |
| Do. . . | (534) J. Ramaswami Reddi. | Do. . . . | M. L. . | 47·99 | 18th January 1907. | 8 years. |
| Do. . . | (535) S. Chinnachenchu Nayudu and S. Venkatapa Nayudu. | Do. . . . | Mining in patta land. | 11·75 | 4th May 1907. | 20 years. |
| Do. . . | (536) V. Kamakshhya . | Do. . . . | Do. . | 4·42 | 28th May 1907. | Do. |
| Do. . . | (537) R. V. Kuppaswami Aiyar. | Do. . . . | P. L. . | 10·08 | 16th April 1907. | 1 year. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L. Mining Lease.

## MADRAS—*contd.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nellore | (538) D. Venkata Rao | Mica | P. L. | 15·32 | 12th April 1907. | 1 year. |
| Do. | (539) D. Pencha Nayudu | Do. | P. L. | 19·42 | 11th June 1907. | Do. |
| Do. | (540) P. Balarami Reddi | Do. | P. L. | 20 | 18th June 1907. | Do. |
| Do. | (541) A. Raghavalu Nayudu. | Do. | E. L. | Unoccupied and reserved lands in the four taluks. | 16th April 1907. | Do. |
| Do. | (542) J. Krishnaswami Nayudu. | Do. | E. L. | Do. | 19th April 1907. | Do. |
| Do. | (543) Muhammad Fasi-ud-din. | Do. | P. L. renewal. | 12·30 | 9th May 1907 | Do. |
| Do. | (544) T. B. Kantharia | Copper | E. L. | All lands at the disposal of Government in four villages. | 6th June 1907. | Do. |
| Do. | (545) R. V. Kuppuswami Aiyar. | Mica | P. L. renewal. | 24·68 | 13th June 1907. | 2 month |
| Do. | (546) Do. do. | Do. | M. L. | 75·76 | 1st June 1907 | 30 years. |
| Do. | (547) Nellore Obulu Reddi. | Do. | P. L. | 22·61 | 5th July 1907 | 1 year. |
| Do. | (548) T. Venkata Reddi | Do. | P. L. | 16·85 | 15th August 1907. | Do. |
| Do. | (549) K. Guruswami Somayajalu | Do. | P. L. | 19·20 | 13th July 1907. | Do. |
| Do. | (550) Do. do. | Do | P. L. | 38·80 | Do. | Do. |
| Do. | (551) Y. Pichi Reddi | Do. | Mining in patta land. | 9·06 | 16th July 1907. | 20 years. |
| Do. | (552) V. Venkatasubbayya Nayudu. | Do. | Do. | 8·20 | 30th August 1907. | Do. |
| Do. | (553) K. Krishnaswamy Mudaliyar. | Do. | P. L. | 14 | 13th July 1907. | Do. |
| Do. | (554) Do. do. | Do. | P. L. | 12·92 | 26th August 1907. | Do. |
| Do. | (555) J. Pattabhi Rama Reddi. | Do. | P. L. renewal. | 18·62 | 25th July 1907. | Do. |
| Do. | (556) Do. do. | Do. | P. L. renewal. | 39·32 | Do. | Do. |
| Do. | (557) B. Chenchuramayya | Do. | Mining in patta land. | 4 | 27th August 1907. | Do. |
| Do. | (558) R. Ramachendra Reddi. | Do. | E. L. | All occupied reserved and unreserved lands. | 20th September 1907. | 1 year. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## MADRAS—*concld.*

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Nellore . | (559) C. Raghavalu Chetti | Mica . . . | Mining in patta land. | 2 91 | 16th September 1907. | 20 years. |
| Do. . . | (560) R. V. Kuppuswami Aiyar. | Do. . . . | Do. | 9·96 | 12th May 1907. | Do. |
| Do. . . | (561) K. Penchala Reddi | Do. . . | P. L. | 14·80 | 18th November 1907. | 1 year. |
| Do .. . | (562) R. V. Kuppuswami Aiyar. | Do. . . | M. L. extension. | 30·08 | 2nd September 1907. | 3 years. |
| Do. . . | (563) Do. do. . | Do. . . | M. L. | 24·68 | 13th August 1907. | 30 years. |
| Do. . . | (564) R. V. Arthanari Aiyar. | Do. . . | P. L. | 19·79 | 1st November 1907. | 1 year. |
| Do. . . | (565) K. Guruswami Somayajulu. | Do. . . | P. L | 19·75 | 8th October 1907. | Do. |
| Do. . . | (566) K. Linga Reddi . | Do. . . | P. L. renewal. | 34·80 | 19th October 1907. | Do. |
| Do. . . | (567) P. Venkatarama Nayudu. | Do. . . | P. L. . renewal. | 36·33 | 16th December 1907. | Do. |
| Do. . . | (568) I. Ramaswamy Reddi. | Do. . . | M. L. extension. | 47·99 | 18th January 1908. | 30 years. |
| Do. . . | (569) R. V. Arthanari Aiyar. | Do. . . | E. L. | Not stated . | 6th December 1907. | 1 year. |
| North Arcot | (570) J. Krishnaswami Nayudu. | Do. . . | E. L. . | Do. | 11th July 1907. | Do. |
| Salem . . | (571) Messrs. G. G. E. Nagarajiah & Co. | Corundum . | E. L. . | 100 | 17th July 1907. | Do. |
| Do. . | (572) Mr. L. Tardival . | Minerals and precious stones. | E. L. . | Not stated . | 9th October 1907. | Do. |
| Trichinopoly | (573) Mr. A. Ghose . | Minerals and mineral oil. | E. L. . | Whole of the taluk excluding inam and private lands. | 29th October 1907. | Do. |
| Vizagapatam | (574 Sri V. V. S. Jagapathi Razu Guru, Zamindar of Kotlam, etc., Godavari. | Graphite . . | M. L. . | 26·50 | 9th August 1907. | 15 years. |
| Do. . | (575) S. Craushaw, Manager, the Madras Manganese Mining Co. | Manganese . | E. L. . | 654,720 | 16th August 1907. | 1 year. |

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

## NORTH-WEST FRONTIER PROVINCE.

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term |
|---|---|---|---|---|---|---|
| Peshawar, Kohat Bannu and Dehra Ismail Khan. | (576) The Burma Oil Co. Ltd. | Petroleum . | E. L. | Settled portions of the North-West Frontier Province situated between Long. 69° 72′ and Lat. 31° 34′ excluding transborder tracts in which Government of India exercises only political control. | 27th April 1907. | 1 year. |

## PUNJAB.

| | | | | | | |
|---|---|---|---|---|---|---|
| Jhelum . | (577) Lala Ganesh Das . | Coal . . | P. L. . | 42 | 9th February 1907. | 1 year. |
| Do. . | (578) Do. do. . | Do. . . | P. L. . | 133 | Do. | Do. |
| Do. . | (579) Do. do. . | Do. . . | P. L. . | 295 | Do. | Do. |
| Do. . | (580) Do. do. . | Do. . . | P. L. . | 325 | Do. | Do. |
| Do. . | (581) Punjab Coal Co. . | Do. . . | P. L. . | 700 | 6th February 1907. | Do. |
| Do. . | (582) Babu Lakhmi Das. | Do. . . | P. L. . | 407 9 | 5th February 1907. | Do. |
| Do. . | (583) Lala Ganesh Lal . | Do. . . | P. L. . | 193·6 | 9th April 1907. | Do. |
| Do. . | (584) Do. do. . | Do. . . | P. L. . | 145·2 | Do. | Do. |
| Do. . | (585) Lala Kishan Lal . | Do. . . | P. L. . | 41·74 | 5th June 1907. | Do. |
| Do. . | (586) Do. do. . | Do. . . | P. L. . | 61·97 | Do. | Do. |
| Do. . | (587) Do. do. . | Do. . . | P. L. . | 86·31 | 24th June 1907. | Do. |
| Do. . | (588) Do. do. . | Do. . . | P. L. . | 116·37 | Do. | Do. |
| Do. . | (589) Rai Sahib Rocharam and Sons. | Do. . . | P. L. . | 233 | 21st June 1906. Renewed till 20th June 1908. | Do. |
| Do. . | (590) Do. do. . | Do. . . | P. L. . | 495 | Do. . | Do. |
| Do. . | (591) Lala Thaker Das . | Do. . . | P. L. . | 32·544 | 8th July 1907. | Do. |

E. L., denotes Exploring License, P. L. Prospecting License, and M. L., Mining Lease.

## PUNJAB.

| DISTRICT. | Grantee. | Mineral. | Nature of grant. | Area in acres. | Date of commencement. | Term. |
|---|---|---|---|---|---|---|
| Jhelum . | (592) Pandit Bhola Nath. | Coal . . | P. L. . | 144 | 31st July 1907. | 1 year. |
| Do. . | (593) Do. do. . | Do. . . | P. L. . | 102·5 | Do. . | Do. |
| Do. . | (594) Lala Thakar Das . | Do. . . | P. L. . | 92·38 | 3rd October 1907. | Do. |
| Do. . | (595) Lala Ishar Das . | Do. . | P. L. . | 164·81 | 10th October 1907. | Do. |
| Mianwali . | (596) Lala Thakar Das, son of Lala Wishen Das. | Do. . . | P. L. . | 957 | 23rd October 1907. | Do. |
| Shahpur . | (597) Pir Chan Pir of Pail. | Do. . . | P. L. . | 624 | 25th July 1907. | Do. |

## UNITED PROVINCES.

| | | | | | | |
|---|---|---|---|---|---|---|
| Almora . . | (598) Mr. R. M. Nash, on behalf of Mr. G. G. Anderson. | Copper . . | P. L. . | 1,057 | 1st June 1907. | 1 year. |
| Do. . | (599) Mr. R. M. Nash on behalf of Mr. W. J. Burn. | Do. . . | P. L. . | 1,017 | Do. | Do. |
| Garhwal . | (600) Mr. R. M. Nash . | Do. . . | M. L. . | 1,195 | 1st October 1907. | 30 years. |

## SUMMARY.

| PROVINCES. | Prospecting licenses. | Exploring licenses. | Mining leases. | Total of each Province. |
|---|---|---|---|---|
| Baluchistan . . . . . . . . | 2 | 1 | 8 | 11 |
| Bengal . . . . . . . . | 41 | .. | 1 | 42 |
| Bombay . . . . . . . . | 34 | 62 | 5 | 101 |
| Burma . . . . . . . | 41 | 9 | 4 | 54 |
| Central Provinces . . . . . | 186 | 76 | 15 | 277 |
| Eastern Bengal and Assam . . . . . | 3 | .. | .. | 3 |
| Madras . . . . . . . . | 38 | 22 | 27 | 87 |
| North-West Frontier Province . . . . | .. | 1 | .. | 1 |
| Punjab . . . . . . . . | 21 | .. | .. | 21 |
| United Provinces . . . . . | 2 | .. | 1 | 3 |
| **Total for each kind and Grand Total, 1907.** | **368** | **171** | **61** | **600** |
| *Totals for* 1906 . . . . . . . | 147 | 41 | 64 | 252 |

E. L. denotes Exploring License, P. L. Prospecting License, and M. L. Mining Lease.

# CLASSIFICATION OF LICENSES AND LEASES.

TABLE 39.—*Prospecting and Mining Licenses granted in Baluchistan during* 1907.

| DISTRICT. | 1907. | | |
|---|---|---|---|
| | No. | Area in acres. | Mineral. |
| **Prospecting Licenses.** | | | |
| Bolan . . . . | 1 | 160 | Coal. |
| Las Bela State . . | 1 | 480,000 | Minerals of all kinds. |
| TOTAL . | 2 | — | |
| **Mining Leases.** | | | |
| Bolan . . . . | 1 | 319·98 | Coal |
| Kalat Bolan . . . | 1 | 57·194 | Do. |
| Kalat Degari . . . | 2 | 71 | Do. |
| Quetta Pishin. . . | 1 | 51·89 | Do. |
| Do. . . | 2 | 160 | Chromite. |
| Zhob . . . . | 1 | 80 | Do. |
| TOTAL . | 8 | .. | |

TABLE 40.—*Prospecting and Mining Licenses granted in Bengal during* 1907.

## Prospecting Licenses.

| | | | |
|---|---|---|---|
| Burdwan . . . | 1 | 1,458·5 | Coal. |
| Hazaribagh . . . | 19 | 1,947·6 | Mica. |
| Singhbhum . . . | 12 | 3,865·6 | Manganese. |
| Do. . . . | 7 | 15,481·6 | Manganese and iron-ore. |
| Do. . . . | 1 | 1,920 | Iron-ore. |
| Do. . . . | 1 | 1,920 | Gold. |
| TOTAL . | 41 | .. | |

## Mining Leases.

| | | | |
|---|---|---|---|
| Gaya . . . . | 1 | 28·26 | Mica. |

TABLE 41.—*Prospecting and Mining Licenses granted in Bombay during* 1907.

| DISTRICT. | 1907. No. | 1907. Area in acres. | 1907. Mineral. |
|---|---|---|---|
| **Prospecting Licenses.** | | | |
| Belgaum | 2 | 921 | Manganese. |
| Bijapur | 1 | 1,109 | Asbestos. |
| Dharwar | 3 | 2,207 | Gold. |
| Do. | 3 | 2,637 | Manganese. |
| Do. | 1 | 1,568 | Graphite and copper. |
| Do. | 1 | 909 | Copper and lead. |
| Kánara | 19 | 25,960 | Manganese. |
| Panch Mahals | 3 | 2,240 | Do. |
| Ratnagiri | 1 | 61 | Do. |
| TOTAL | 34 | .. | |
| **Mining Leases.** | | | |
| Dharwar | 2 | 1,526 | Gold. |
| Panch Mahals | 3 | 528 | Manganese. |
| TOTAL | 5 | .. | |

TABLE 42.—*Prospecting and Mining Licenses granted in Burma during* 1907.

## Prospecting Licenses.

| | | | |
|---|---|---|---|
| Amherst | 1 | 309·14 | Antimony. |
| Bassein | 1 | 3,200 | Coal. |
| Bhamo | 2 | 5,940 | Gold. |
| Henzada | 2 | 5,120 | Coal. |
| Katha | 2 | 3,081·5 | Copper, lead, etc. |

| DISTRICT. | 1907. | | |
|---|---|---|---|
| | No. | Area in acres. | Mineral. |

## Prospecting Licenses.—*contd.*

| DISTRICT. | No. | Area in acres. | Mineral. |
|---|---|---|---|
| Katha . . . | 1 | 1,350·4 | Coal. |
| Mandalay . . . | 2 | 308·83 | Iron-ore. |
| Mergui . . . . | 5 | 10,545·83 | Tin. |
| Myingyan . . . | 7 | 22,202·33 | Petroleum. |
| Myitkyina . . . | 1 | 6,400 | Gold, copper, platinum, etc. |
| N. Shan States . . | 2 | 6,400 | Silver, lead and allied mineral. |
| Do. . . . | 2 | 3,200 | Copper. |
| Pakôkku . . . | 3 | 4,480 | Petroleum. |
| S. Shan States . . | 2 | 1,280 | Coal. |
| Do. . . . | 1 | 1,920 | Copper. |
| Do. . . . | 1 | Not stated | Antimony and other ores |
| Do. . . . | 1 | Do. | All minerals. |
| Tavoy . . . . | 2 | 2,896 | Do. |
| Thayetmyo . . . | 1 | 640 | Petroleum. |
| Toungoo . . . | 1 | 3,200 | Silver, lead and other metals. |
| Yamethin . . . | 1 | 1,280 | Do. do. |
| TOTAL . | 41 | .. | |

## Mining Leases.

| DISTRICT. | No. | Area in acres. | Mineral. |
|---|---|---|---|
| Akyab . . . . | 1 | 500 | Coal. |
| Mandalay . . . | 1 | 160 | Silver and lead. |
| Mergui . . . . | 1 | 1,955·72 | Tin. |
| N. Shan States . . | 1 | 10,240 | Silver, copper, lead and zinc. |
| TOTAL . | 4 | .. | |

**TABLE 43.**—*Prospecting and Mining Licenses granted in the Central Provinces during 1907.*

| DISTRICT. | 1907. | | |
|---|---|---|---|
| | No. | Area in acres. | Mineral. |
| | **Prospecting Licenses.** | | |
| Balaghat . . . | 45 | 10,318 | Manganese. |
| Do. . . . | 1 | 1,316 | Manganese, bauxite and iron. |
| Do. . . . | 1 | 607 | Mica. |
| Do. . . . | 1 | 11 | Mica, corundum and dolomite. |
| Bhandara . . . | 49 | 14,589·68 | Manganese. |
| Do. . . . | 1 | 57 | Mica. |
| Do. . . . | 1 | 1,300 | Asbestos. |
| Do. . . . | 2 | 341 | Manganese, iron-ore and galena. |
| Do. . . . | 2 | 513 | Mica, corundum and dolomite. |
| Chhindwara . . . | 26 | 4,317 | Manganese. |
| Do. . . . | 1 | 52 | Copper. |
| Hoshangabad . . | 2 | 25,043 | Coal. |
| Do. . . . | 1 | 10 | Galena. |
| Jubbulpore . . . | 4 | 855 | Manganese. |
| Do. . . . | 4 | 7,151 | All minerals. |
| Do. . . . | 1 | 294 | Bauxite. |
| Nagpur . . . | 24 | 4,247 | Manganese. |
| Narsinghpur . . . | 1 | 76 | All minerals. |
| Saugor . . . . | 1 | 90 | Do. |
| Seoni . . . . | 17 | 4,848·44 | Manganese. |
| Yeotmal . . . | 1 | 14,050·35 | Coal. |
| TOTAL . | 186 | ... | |

TABLE 43.—*Prospecting and Mining Licenses granted in the Central Provinces during* 1907—continued.

| DISTRICT. | 1907. | | |
|---|---|---|---|
| | No. | Area in acres. | Mineral. |
| **Mining Leases.** | | | |
| Balaghat . . . | 5 | 920 | Manganese. |
| Bhandara . . . | 2 | 573 | Do. |
| Do. . . . | 1 | 42 | Asbestos. |
| Chhindwara . . . | 1 | 63 | Manganese. |
| Hoshangabad . . | 1 | 254 | Gold, silver, etc. |
| Jubbulpore . . . | 1 | 148 | Manganese and iron. |
| Nagpur . . . | 4 | 76 | Manganese |
| TOTAL | 15 | .. | |

TABLE 44.—*Prospecting Licenses granted in Eastern Bengal and Assam during* 1907.

## Prospecting Licenses.

| | | | |
|---|---|---|---|
| Chittagong . . . | 1 | 2,675·20 | Coal, oil, gold etc. |
| Lakhimpur . . | 1 | 59,424 | Mineral oil. |
| Do . . . | 1 | 9,51· 80 | Coal |
| TOTAL | 3 | .. | |

TABLE 45.—*Prospecting and Mining Licenses granted in Madras during* 1907.

## Prospecting Licenses.

| | | | |
|---|---|---|---|
| Anantapur . . . | 1 | 20·37 | Diamonds. |
| Bellary . . . . | 2 | 54·69 | Manganese. |
| Godavari . . . | 1 | 279·96 | Iron, manganese and graphite. |
| Guntur . . . . | 2 | 15·88 | Copper. |

TABLE 450—*Prospecting and Mining Licenses granted in Madras during* 1907-contd.

| District. | 1907. No. | Area in acres. | Mineral. |
| --- | --- | --- | --- |
| **Prospecting Licenses**—*contd.* | | | |
| Guntur | 1 | 13·84 | Precious stones. |
| Do. | 1 | 400 | Copper, lead, silver and gold. |
| Malabar | 1 | Not stated | Gold. |
| Nellore | 29 | 641·84 | Mica. |
| TOTAL | 38 | ... | |
| **Mining Leases.** | | | |
| Coimbatore | 1 | 5·88 | Corundum. |
| Nellore | 25 | 1,972·97 | Mica. |
| Vizagapatam | 1 | 26·50 | Graphite. |
| TOTAL | 27 | .. | |

TABLE 46.—*Prospecting Licenses granted in the Punjab during* 1907.

**Prospecting Licenses.**

| | | | |
| --- | --- | --- | --- |
| Jhelum | 19 | 3,712·32 | Coal. |
| Mianwali | 1 | 957 | Do. |
| Shahpur | 1 | 624 | Do. |
| TOTAL | 21 | .. | |

TABLE 47.—*Prospecting and Mining Licenses granted in the United Provinces during* 1907.

**Prospecting Licenses.**

| | | | |
| --- | --- | --- | --- |
| Almora | 2 | 2,074 | Copper. |

**Mining Lease.**

| | | | |
| --- | --- | --- | --- |
| Garhwal | 1 | 1,195 | Copper. |

Table 48.—*Summary of Concessions granted in Government lands during the ten years* 1898 *to* 1907.

| Year. | Mining and Prospecting Licenses. | Exploring Licenses. | Total. |
|---|---|---|---|
| 1898 . . . . . . . | 85 | 1 | 86 |
| 1899 . . . . . . . | 47 | 13 | 60 |
| 1900 . . . . . . . | 61 | 11 | 72 |
| 1901 . . . . . . . | 89 | 15 | 104 |
| 1902 . . . . . . . | 89 | 16 | 105 |
| 1903 . . . . . . . | 84 | 16 | 100 |
| 1904 . . . . . . . | 125 | 26 | 151 |
| 1905 . . . . . . . | 145 | 44 | 189 |
| 1906 . . . . . . . | 211 | 41 | 252 |
| 1907 . . . . . . | 539 | 61 | 600 |

# ON THE OCCURRENCE OF STRIATED BOULDERS IN THE BLAINI FORMATION OF SIMLA, WITH A DISCUSSION OF THE GEOLOGICAL AGE OF THE BEDS. BY SIR T. H. HOLLAND, K.C.I.E., D.Sc., F.R.S., *Director, Geological Survey of India* (WITH PLATE 1).

THE "Blaini group" of strata in the Outer Himalaya of the Punjab and United Provinces was so named and first described by H. B. Medlicott in 1864.[1] One of the beds in this group was described as a "conglomerate"; but attention was not drawn to the unusual nature of the formation until Mr. R. D. Oldham pointed out in 1887[2] that the term "conglomerate" used by Medlicott was inappropriate, as the fine-grained slaty matrix in which the boulders lie is often in excess of the volume of the pebbles. Mr. Oldham concluded that the peculiar characters of the beds could only have been obtained by the agency of floating ice, from which stones of various sizes originally lying on, or embedded in, the parent glaciers were dropped into the silt that was accumulating in the neighbouring sea. Oldham mentioned instances of boulders on which there were markings, possibly due to glacial action, but he evidently regarded these scratches with some suspicion in consequence of the fact that the beds had been greatly disturbed by the earth-movements, and the markings on the pebbles might thus have been caused by the movement of the gritty matrix over the surfaces of the pebbles.[3]

In spite, however, of the absence of this particular form of positive evidence, Oldham was of opinion that the glacial theory was the only one that accounted satisfactorily for the peculiar characters of the Blaini boulder-beds.

Most geological visitors to Simla have probably taken the opportunity of examining these beds on the off-chance of finding scratched pebbles, and ill-defined marks are not uncommon. The boulder represented on plate 1, however, shows the essential signs of glaciation to an unmistakable degree, and may thus be regarded

1 *Mem. Geol. Surv., Ind.*, III, Part 2, p. 30.

2 Geology of Simla and Jutogh, *Rec. Geol. Surv Ind.*, XX.

3 Manual, Geol. Ind., 2nd Ed., 1893, p. 133.

as a district confirmation of Mr. Oldham's views. It measures 20 × 12 × 7 centimetres, and the two smoothed faces, approximately parallel to one another, are scored by deep, well-defined striæ, that form, on one of the faces especially, two principal systems of lines crossing one another. The other faces of the stone, which are in no way smoothed, are covered with a rusty crust that shows in section at the junctions with the smoothed faces. The rusty crust was thus presumably on the boulder before it became subjected to the process of grinding, and has been filed off to form the two smoothed and striated faces.

Another scratched boulder, found by Mr. E. H. Pascoe, measures 53 × 30 × 19 centimetres. Although the striations are quite noticeable also on this boulder, the additional features of smoothed faces have not been developed, and the systems of striations accordingly show less pronounced constancy. The characters are, however, as well pronounced as those generally found in the boulders of a modern moraine.

In his account of the Geology of Simla and Jutogh[1], Mr. Oldham pointed out that two distinct boulder-beds are exposed in the Simla area; the upper bed, occurring underneath the bed of magnesian[2] limestone, being the only one referred to by Mr. Medlicott. The two beds are separated by about 200 feet of thin bedded shales or slates, which are black when freshly exposed to considerable depths, but show a peculiar cream-coloured tint on weathered surfaces, and are thus referred to by Mr. Oldham as "bleach slates". The striated boulders now described were obtained from the lower bed exposed in a road-cutting near the Mayo Institute, Simla.

The late W. T. Blanford appears to have been the first to suspect that the Talchir boulder-bed in Orissa was due to ice-action;[3] but it was not till 1872 that striated boulders were found in this formation, and then also the beds were found to be resting on a grooved and striated floor of Vindhyan limestone in the Godavari valley.[4] In this year also W. T. Blanford called attention to the significant resemblance between the boulder-bed under the Karroo

[1] *Loc. cit.*, p. 144.

[2] Lieutenant-General C. A. McMahon showed that near the Blaini river this bed contained about 36 per cent. $MgCO_3$, while a sample from near Barana contained 33·8 per cent. $MgCO_3$ (*Rec. Geol. Surv. Ind.*, X, 1877, p. 210, 212).

[3] *Mem. Geol. Surv. Ind.*, I, p. 49 (1856).

[4] T. Oldham: *Mem. Geol. Surv. Ind.*, IX, p. 324, f.n. (1872).

system in South Africa and that at the base of the corresponding Lower Gondwana system in India,[1] while as far back as 1861 Dr. T. Oldham had called attention to similiar lithological characters in the coal-bearing systems of New South Wales,[2] where R. D. Oldham[3] discovered the first striated boulder in 1885.

The subsequent general recognition of glacial phenomena in places so widely separated as India, Australia and South Africa, at apparently the same geological horizon, gave rise to the idea that the phenomena were contemporaneous and due to a general refrigeration of at least this part of the globe. The correlation of the beds of obvious glacial origin in these three continents with the Permian breccias of England, considered by Sir Andrew Ramsay to be due also to ice-action, suggested the idea that the refrigeration was more than local.[4]

The inference that all these glacial phenomena were contemporaneous naturally suggested the same age for those occurrences of apparently glacial boulder beds of which the age could not be determined by other and independent evidence. Consequently it was assumed, when R. D. Oldham[5] pointed out the probable glacial character of the two boulder-beds in the Blaini formation near Simla, that these beds must also be of Upper Palæozoic age and equivalent to the Talchir boulder bed.[6]

The inference was perfectly natural; one would be justified in assuming that a phenomenon so unusual as a widespread glaciation having left its marks on parts of Peninsular India, and in the Salt Range of the Punjab, was the probable cause also of similar marks in the adjacent Simla region and Kashmir. And the Blaini boulder-bed having been accepted as a reliable horizon of known age, the sequence of strata below and above it in the Simla region became distributed accordingly along the standard stratigraphical scale; those below the Blaini beds were regarded as Permian or older, and those above Permian or younger.

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1 *Mem. Geol. Surv. Ind.*, IX, p. 325.

2 *Mem. Geol. Surv. Ind.*, III, p. 209.

3 *Rec. Geol. Surv. Ind.*, XIX, p. 44.

4 H. F. Blanford: *Quart. Journ. Geol. Soc.*, XXXI, 1875, p. 530 *et seq.*: R. D. Oldham, *Quart. Journ. Geol. Soc.* L, 1894, pp. 469, 470: E. Koken, *Neues Jahrb f. Min. Geol. u. Pal.*, 1907, pp. 446—546.

5 *Rec. Geol. Surv. Ind.*, XX, 1887, p. 144.

6 R. D. Oldham, *Rec. Geol. Surv. Ind.*, XXI, 1888, p. 142.

Nevertheless, some of us had felt that the absence of fossils throughout the great thicknesses of apparently suitable strata in the Outer Himalayas, and the contrast between these rocks and the remarkable succession of fossiliferous beds on the Tibetan side of the central range of crystalline peaks, needs special explanation. One might rest satisfied perhaps with the assumption that the unfossiliferous nature of a stratum to the south of the crystalline axis is due to some local accident that did not affect the formation of beds of the same age on the Tibetan side. Such an accident might perhaps be repeated even in two or three successive periods without raising suspicion, recalling even the development of the well-known *Flysch* facies among the Cretaceous and Tertiary systems; but when one notices that, on the Tibetan side of the snowy peaks, every period from the Lower Palæozoic to the top of the Mesozoic is marked by highly fossiliferous strata, while to the south great thicknesses of strata are absolutely devoid of fossils, one naturally wonders whether these two sets of strata do in reality correspond in age, whether, in fact, it is possible that the waters in which the southern beds were formed were always devoid of living beings, while only a few miles away the ocean always was teeming with life.

Knowing that in Peninsular India there occur great unfossiliferous formations certainly older than the Talchir boulder-bed, it was naturally suspected that the northerly extension of these became caught up in the earth-folds that made the Himalayan range, and that the unfossiliferous rocks of the Outer Himalayas are but parts of the Peninsular systems of unfossiliferous rocks, and thus also pre-Talchir in age.

So long as the widespread glaciation of Talchir times was the only one of the kind known, the presence of a typical boulder-bed in the Simla section could be produced as a serious stumbling block in the way of those who regarded the Simla rocks as older than the Talchirs. But evidences of glaciation have since been found in South China, in Australia, and in South Africa, as well as in the western part of the Northern Hemisphere, among strata very much older than the Talchirs.

In China boulder-beds of probably glacial origin were discovered near Nan-t'ou (31°N; 111°E.) by the expedition sent out under the auspices of the Carnegie Institution and conducted by Bailey Willis. The beds occur below the Ki-sin-ling (Sinian) limestone

which elsewhere yielded Lower and Middle Cambrian fossils, and are separated from the limestone formation by a thin bed of conglomerate, not necessarily representing any great interval of time.[1]

The remarkable development of glacial boulder-beds below the Cambrian in South Australia has recently been fully described by the Revd. W. Howchin.[2]

In South Africa two periods older than the Talchir (Dwyka) beds are marked by glacial phenomena — that in which the Table Mountain Sandstone was formed in Lower Devonian, or possibly pre-Devonian, times,[3] and the much earlier, possibly even Huronian,[4] period in which the Griquatown series was formed.[5]

On the coast of the Varangar fiord in Norway glacial phenomena have been described by H. Reusch and A. Strahan in a formation occurring below the Gaisa beds, which are regarded as equivalent to the Lower Cambrian or possibly pre-Cambrian sparagmite formation of Central and South Norway.[6]

Less certain signs of glacial action have been referred to by H. Hicks as indicated by certain pre-Cambrian rocks of Wales,[7] while in the new mining district of Cobalt, North Ontario, A. P. Coleman has described striated and "soled" boulders in a slaty matrix forming part of the Huronian rocks.[8]

When it was generally assumed that glaciation involved a widespread refrigeration appreciably affecting most, and possibly affecting, all, the globe, and when the phenomenon was considered to be a rare occurrence in past ages, naturally there was a tendency to regard such occurrences as probably contemporaneous. The theory of a world-wide refrigeration is not, however, universally accepted, and thus the extra-Indian glacial beds would give us no reliable clue to the age of the Blaini formation, even if we had but one pre-Talchir glaciation to consider. We are, therefore, no more able to give an age for the Simla rocks now than we

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1 Research in China: E. Blackwelder, Vol. I, Part I, Chapter XII; B. Willis, Vol. II, p. 39 (1907).

2 *Quart. Journ. Geol. Soc.*, LXIV, p. 234 (1908).

3 A. W. Rogers, *Trans. S. African Phil. Soc.*, XI, 1902, pp. 236—242; XVI, 1904, pp. 1—8.

4 E. H. L. Schwarz. *Trans. Geol. Soc. S. Africa*, VIII, 1905, p. 95.

5 Rogers, *Trans. Geol. Soc. S. Africa*, IX, 1906, pp. 8, 9. Schwarz, *Journ. Geol.*, XIV, 1906, p. 685.

6 A. Strahan, *Quart. Journ. Geol. Soc.*, LIII, p. 137 (1897) and literature quoted.

7 *Geol. Mag.*, 1876, p. 157 and 1880, p. 488—491.

8 *Journ. Geol.*, XVI (1908), p. 149.

were before the signs of very old glaciation in the Southern Hemisphere and South China were known. These occurrences have, however, relieved us from the obligation of correlating the Blaini boulder-beds with those of the Upper Carboniferous Talchir series, and those who maintain that the unfossiliferous strata of the Outer Himalayas should be correlated with the pre-Talchir unfossiliferous systems of Peninsular India have no longer the boulder-bed difficulty to apologise for.

A boulder-bed has been recognised among the pre-Vindhyan rocks of the Son valley in Central India, but the positive signs usually accepted as evidences of glaciation have not been detected in this formation.[1] It is impossible, therefore, to accept this as a suggestion for correlation in the absence of other parallel features. Meanwhile, in order to accommodate the great post-Dharwar unfossiliferous systems of the Peninsula and their probable representatives in the Outer Himalayas, I have elsewhere[2] suggested the group name *Purana*, on the supposition that these systems are probably in part or wholly pre-Cambrian in age, and perhaps the Indian representatives of the great post Huronian, pre-Upper Cambrian formations so well known from the occurrences in Canada and the United States.

## Summary.

The occurrence of characteristically smoothed and striated boulders supports Oldham's conclusion as to the special origin of the Blaini beds in the Outer Himalaya of the Punjab and United Provinces.

The recent discovery of glacial boulder-beds much older than the Talchir-Dwyka horizon in South China, Australia and Africa, in addition to the evidences of very ancient glaciations in more northerly latitudes, shows that the Talchir glaciation in Peninsular India, being only one of many such phenomena, cannot be accepted as necessarily equivalent to the Himalayan glacial beds.

This conclusion removes the principal objection to the arguments in favour of regarding the unfossiliferous systems of the Himalayan region to be outliers of those south of the Indo-Gangetic alluvial plain, which are known to be pre-Talchir (pre-Upper Carboniferous) in age.

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[1] R. D. Oldham, *Mem. Geol. Surv. Ind.*, XXXI, 1901, p. 132.

[2] Presidential Address: *Trans. Min. and Geol. Inst., India*, Vol. I, 1906, p. 19.

The unfossiliferous systems of the Outer Himalayas, and those of pre-Talchir (pre-Upper Palæozic), post Dharwar (post Huronian) age in the Peninsula of India are placed provisionally in one group distinguished by the name Purana. The systems in this group cannot be correlated with those of the standard scales of Europe and America, but they are probably wholly or in part pre-Cambrian in age.

# MISCELLANEOUS NOTES.

## Note on Jurassic and Triassic fossils from Nepal.

Mr. F. R. Cowper Reed has recently made an important discovery of fossils from Nepal that have been lying unnoticed in the collections of the Sedgwick Museum, Cambridge, since 1872.[1] According to the label preserved with the specimens, the fossils were obtained from "the Salagrammi River near Mooktinath," and were presented by Dr. Wallich to "T. F. C.," presumably Major-General T. F. Colby, F.R.S., in 1822. Dr. N. W. Wallich was Superintendent of the Royal Botanic Gardens, Sibpur, from 1815 to 1846, and, as shown by his papers in the *Transactions of the Asiatic Society of Bengal,* described various collections of plants from Nepal. It is possible, therefore, that, with the plants, he obtained the fossils referred to by Mr. Reed.

The fossiliferous rocks lying to the north of the crystalline, snow-covered peaks in Spiti and Garhwal have been studied in considerable detail by the Geological Survey of India.[2] The occurrence of Spiti shales and other Jurassic beds in Eastern Tibet to the north of Sikkim was also definitely established by Mr. Hayden[3] when attached to the Younghusband Mission in 1903-1904. The recognition of Jurassic fossils from Mukhtinath, which lies to the north of the Nepalese crystalline peaks, thus helps to fill in the gap and confirms the conclusion that on the Tibetan side of the crystalline axis of the Himalayan range there is a continuous zone of marine sediments, indicating approximately the northern coast line of the old Gondwana continent.[4]

Mr. Reed has made provisional determinations of the fossils now found in the Sedgwick Museum, and points out that they are nearly all closely related to known forms in the Spiti shales of Kumaon and Garhwal. Two specimens, however, have Triassic affinities, and it is thus probable that Triassic as well as Jurassic strata occur to the north of Nepal. The Jurassic (Upper Jurassic) forms include:—*Belemnites* cf. *sulcatus* Miller, *Hoplites*

1 *Geol. Mag.*, Decade V, Vol. V, p. 256, June, 1908.

2 *Cf.* Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, Part I, 1904, and literature quoted. *Pal. Ind.*, series XV, Vols. I—V.

3 *Mem. Geol. Surv. Ind.*, XXXVI, Part 2, p. 156, 1907.

4 *Cf.* General Report, G. S. I., for 1903-04, *Rec. Geol. Surv. Ind.*, XXXII, pp. 153, 154, 1905.

*Wallichii* Gray, *Perisphinctes* cf. *biplex* Sow., *P.* cf. *torquatus* Sow., P. aff. *frequens* Oppel, *P.* cf. *sabineanus* Oppel, *Oppelia* (*Streblites*) cf. *Griesbachi* Uhlig, *Parallelodon egertonianus* Stoliczka, *Nucula* sp. *Rhynchonella* cf. *variabilis* Schloth.

Mr. Reed's discovery clears up the doubts that have long been entertained regarding the "Saligram" question. The name has long been applied to rounded black stones regarded as sacred by the Hindus. Some of these are concretionary bodies with nuclei of Jurassic Ammonites, such as are commonly found in the Spiti shales; but many of the so-called Saligrams obtainable in Indian bazars are black rounded pebbles of various kinds of rocks, and presumably, therefore, business instincts have given rise to a wider application of the name, the outward and visible features being not always accompanied by the internal structure that is supposed to be essentially connected with the sacred character of the stone.

Ammonites from the Spiti shales, with and without the concretionary envelopes, have long been brought into India from the North-Western Himalayas, and it was in consequence of this fact that Dr. W. T. Blanford doubted the Nepalese origin of Dr. J. E. Gray's type-specimens, said to have been obtained from "Sulgranees.[1]"

Dr. Blanford thought "Sulgranees" must have been a mistake for "Saligram," and that the Ammonites had been obtained from the North-West, where similar Ammonites were known in the Spiti shales. It now appears from Mr. Reed's discovery, that Spiti shale Ammonites were undoubtedly obtained from the north of Nepal, and, as pointed out by Lieutenant-Colonel Wilford,[2] the river Gandak, which rises in Nepal, is locally known as the "Sallagramma" because of the stone of that name found in its bed. The specific names given by Gray, *A. nepalensis* and *A. Wallichii*, generally agree with the labels preserved in the Sedgwick Museum in indicating that Gray's specimens were obtained from Nepal through the agency of Dr. Wallich, while Mr. Hayden's work further east in Tibet shows that the Spiti shales are continued in that direction on the northern flanks of the crystalline peaks, and are thus almost certainly to be found also to the north of Nepal.

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1 *Proc., Malacol., Soc.*, V, 1903, p. 345, and *Rec. Geol. Surv Ind.*, XXXI. 1904, p. 46.
2 *Trans. As. Soc.* (*Beng.*), XIV, 1822, p. 415.

The fossils obtained by Mr. Hayden from the crushed rocks regarded as probably Triassic in age in Eastern Tibet could not be identified, even generically, and it is thus not possible to correlate these with the Triassic fossils recognised by Mr. Reed in the collections from near Mukhtinath in Nepal.

T. H. HOLLAND.

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# THE TERTIARY AND POST-TERTIARY FRESHWATER DEPOSITS OF BALUCHISTAN AND SIND WITH NOTICES OF NEW VERTEBRATES. BY GUY E. PILGRIM, B.SC., F.G.S., *Geological Survey of India.* (With Plates 2, 3 and 4.)

## INTRODUCTION.

**Previous ideas on the Siwalik series.**

FOR many years it has been usual to group all the Tertiary freshwater beds of India, in which bones have been found, under the general designation of Siwalik. At the same time they have broadly been spoken of as Pliocene, with a corollary, often feebly expressed, that the basal beds of the series probably date back into the Upper Miocene. The apparent admixture of Oligocene, Miocene and Pliocene species has been a puzzle to many, but has for the most part been explained away by assuming that in tropical climates the older species survived after their extinction in the Temperate zone. As long ago as 1876 Lydekker was fully cognisant of the older facies presented by the vertebrate remains of Sind and Baluchistán, but he seems to have been prevented from assigning to the beds an age corresponding to their fossils by the consideration that the marine Gaj, which directly underlay them, was accepted without question as Upper Miocene. Now that it has been settled that the age of the Gaj cannot be newer than burdigalian, such an objection no longer exists and we are in a position to consider the age of this fauna fairly, and on its own merits.

**A revision of former views necessary.**

**The present writer's contribution to the question.**

In a recent paper in the Records[1] the present writer suggested, mainly on palæontological grounds, that the beds in the Bugti hills, from which a small collection of both vertebrate and invertebrate fossils had been made, was older than the Siwalik and probably contemporaneous with the marine Gaj of Sind. A visit to this country in the early part of this year has enabled me to settle the point definitely.

At the time when I wrote my previous paper I was under the impression that all the fossils had been found in the same beds. It appears however that *Tetrabelodon angustidens*, *T. pandionis* and *T. falconeri* are not associated with the anthracotheroid fauna and the mollusca of which Blanford wrote descriptions; but an unconformity occurs between the two series of strata. As will be shown further on, the older of these two faunas may be regarded as aquitanian in age and the younger, which is truly Lower Siwalik, as sarmatian—with a possibility of its being even older than that.

The results obtained as a whole are interesting, and it is with the object of making them known that the present paper is mainly written. In connection with them a general review of the whole set of freshwater deposits met with in Sind and Baluchistán may not be out of place.

**The existence of four freshwater Series in Sind and Baluchistán.**

It is certain that in the Bugti hills there exist four distinct freshwater deposits, each of which is unconformable to the others. Three of them show more or less sign of disturbance and two of them are ossiferous. The fourth consists of horizontally-bedded gravels and conglomerates, which probably date from the Pleistocene, but as they give no definite indication of their age they may be generally referred to here merely as Post-Tertiary. Adhering to previous nomenclature these may be named in descending order :—

1. Post-Tertiary.
2. Upper Siwalik.
3. Lower Siwalik.
4. Upper Nari.

[1] *Rec., Geol. Surv. Ind.*, XXXVI, p. 45.

This classification also holds good for Sind and other parts of Baluchistán, although in Sind a marine formation occurs between the Upper Nári and the Lower Siwalik, while an upper division of the Lower Siwalik seems to be added, which may be known as Middle Siwalik.

## UPPER NÁRI.

### The Upper Nári series of the Bugti and Marri country.

Before dealing with the palæontology it will be convenient to first describe the beds generally and give an account of their stratigraphy.

The ossiferous Upper Nári series of the Bugti country attains a thickness of 1,000 feet, the rocks are subject to considerable lateral variation, and it is often difficult to trace any particular bed for more than a short distance. As it happens, the same fossil species occur at different horizons, so that it has been found impracticable to regard the series otherwise than as a whole. It consists for the most part of sandstones, which are often of various bright colours. They pass here and there into red and yellow sandy clays. The sandstones differ from those of the Lower Siwaliks by their coarseness. They are frequently true grits with numerous quartz pebbles of the size of a pea. Beds of concretionary iron, sometimes conglomeratic in character and sometimes resembling laterite, are common. Ferruginous conglomerates are particularly well developed in Puli nala, north of Dera Bugti, near the base of the series, where some 200 feet of them occur with intercalated sandstones. Beds of an almost pure white sandstone containing lenticular bands and patches of black or dark red ferruginous matter occur. These standstones are in some places soft and form well rounded ridges and hillocks, looking like sandhills, and occasionally actually covered with some quantity of drift sand, while in others they are harder and resist weathering. One type is exceedingly characteristic of the series—in the Bugti area at all events. In this the sandstone has been hardened by some concretionary action along branches or in knobs, so that the result of the weathering of the softer sandstone in between has been to produce a surface which is

**Lithological character.**

honeycombed by ramifying passages or pits. This bed forms the top of scarps and, as it occurs rather high up in the series, it is generally one of the first beds to be recognized when the boundary between the Lower Siwaliks and the Náris is crossed. An exceedingly characteristic form of concretion consists of numerous quartz fragments, up to the size of a pea, either well rounded or somewhat angular, cemented with and entirely coated by dark red iron oxide, and aggregated into spherical masses of all sizes up to that of a man's head. These beds on the whole are readily distinguished from the Lower Siwaliks by the much coarser nature of the sandstones, the abundance of small quartz pebbles, and the frequency of ferruginous bands, as also by the absence of the calcareous pseudo-conglomeratic sandstone and the "pepper and salt" sandstones so characteristic of the Lower Siwaliks. It may be noted that some 100 feet above the base of the Nári series in the Bugti area a massive sandstone is found with conglomerate beds that bear some resemblance to the Lower Siwalik basal concretionary bone conglomerates. They contain however more ferruginous matter and occasionally contain oysters but no bones.

**Lithological differences from the Lower Siwaliks.**

The pebbles contained in this bed and elsewhere in some of the Nári conglomerates are none of them of limestone, but are either of sandstone or quartzite, and can often be recognized as having been derived from the sandstones of the Cretaceous.

**Pebbles, whence derived.**

At an horizon, which is not quite constant, but occurs from 500 to 700 feet above the base of the Nári, is a zone of freshwater shell beds. These shell beds seem to mark the former sites of ponds or swamps. Ripple markings have been noticed on some of the sandstones near these shell beds at Gandoi, Abband and Singsila. *Paludina bugtica* Blanf. is the chief fossil, almost entirely making up the substance of a band of limestone some 6 inches thick. At Kumbhi and Iliasi the shells occur in more scattered fashion either in the coarse sandstones or in conglomerates. *Melania* occurs in the former, *Unio* in the latter.

**Freshwater shell beds.**

Silicified tree trunks of exogenous wood occur in great abundance in the yellow sandstones at a horizon some 300 feet above the base of the series,

**Fossil wood.**

**Vertebrate remains.**

Fossil bones and teeth are met with at various horizons, from the base of the series up to within 100 feet of the top, on either side of the Zen range south of Dera Bugti and the Sihaf valley, particularly near Gandoi and Kumbhi which are situated on the same meridian on exactly opposite sides of the range. They are also found, but less abundantly, at one or two places further eastward, Khajuri, Pakti, Abband in the Shori nala. They have not been discovered north of Gandahari hill, in the outcrop which runs to Dera Ghazi Khan, nor in any place north of the Sihaf or Dera Bugti valley. Unfortunately, though well preserved, they are for the most part isolated fragments of small size.

**Marine stage at base.**

It is probable that at the base of the series there everywhere exists a marine band representative of the top of the so-called Lower Nári, that is to say, the highest horizon of the stampian. It is recognized by the occurrence of *Nummulites intermedius* and *Pecten* sp. These fossils occur sometimes in one or more bands of brown limestone some 3—6 feet thick producing quite a feature on the landscape, but in other places nummulites and *Pecten* are in a loose sandstone, while in other places again the nummulites are absent and *Pecten* sp. alone is found; and, lastly, the same peculiar greenish-brown sandstone rests on the Khirthars, perhaps only one or two inches thick and containing either no fossils, or only poorly preserved *Pectens* found after a prolonged search.

**Dakko section.**

In Dakko nala some 5 feet, thinning away to a few inches, of yellowish to greenish sand or sandy shale lies directly on the Upper Khirthar limestone. This passes into brown Nári limestone. Above this are characteristic reddish-brown shales with an intercalated bed of brown sand, all containing abundant gypsum and ferruginous matter. Above this again is a 2-foot band of hard Nári limestone with numerous nummulites. Lying on this is a ferruginous sand and a very hard sandstone simulating a quartzite in places. This last is very characteristic of this zone in the Bugti hills. All these beds dip perfectly conformably to the Khirthars.

**Kisharik section.**

In Kisharik nala north of Dera Bugti a 4-inch pebble bed with well rounded nummulitic limestone pebbles lies on the Khirthar limestone. This passes up into a greenish argillaceous sand with numerous *Nummulites intermedius*.

**Kumbhi section.**

At Kumbhi *Nummulites intermedius* occurs in a pebbly sandstone, while a 2-foot band of brown limestone contains nummulites and *Pecten* sp. along with numbers of *Echinolampas radakensis* Dunc. and Slad. n. var., which passes imperceptibly above and below into a yellow sandstone.

**Khajuri section.**

**Bones in the marine band.**

**Oysters associated with the vertebrate fauna.**

Between Khajuri and Shori nalas I have traced continuously, along the Khirthar boundary, a soft yellowish-brown sandstone with black specks, varying from 2 inches to a foot thick, containing in one place *N. intermedius*, *Pecten* sp. and *Pecten sabstriatus* D'Orb. and several sharks' teeth, and below them a gypsiferous layer with vertebrate bones. Along most of the outcrop, however, *Pecten* alone is found associated with three species of *Ostrea*, one of which my colleague, Mr. E. W. Vredenburg, has identified with the Nári form of *Ostrea elegans* L. This band passes up into red clays and sands with ferruginous bands laterally passing into white sand with lenticular ferruginous masses. Here are found abundance of Reptilian and Chelonian remains, Proboscidean and Rhinoceros bones and teeth, *Brachyodus* sp. and *Anthracotherium bugtiense* accompanied by the same species of oyster. Locally a ferruginous conglomerate replaces the basal brown sand. Other places where the same association of oysters and vertebrate remains occurs are Pishi nala, S. E. of Dera Bugti and above Gujru nala near Pakti. Basal beds of a similar lithological character have been found almost everywhere directly lying on the Khirthars, though both marine and estuarine fossils appear to be frequently absent. It is, therefore, evident that a marine stage occurring at the end of the stampian was gradually succeeded by estuarine and finally by freshwater conditions as the land rose.

**Upper Nári overlain by Lower Siwaliks.**

The series is overlain by characteristic red and grey clays of the Lower Siwaliks, with which are soft crumbly sandstones having numerous interbedded conglomerates of a concre-

tionary nature abounding in pellets of limestone and red clay. These beds invariably occur at the base of the Lower Siwaliks in Baluchistán and Sind and are always ossiferous, though the fossils are generally very badly preserved.

**Distribution of Upper Nári in Baluchistán.**

The distribution of this series may now be noticed. Well developed both north and south of the Sihaf plain, it attains almost its maximum thickness at Gandoi and Kumbhi.

**Overlap of Upper Nári by Lower Siwaliks.**

It dies away going westward on both sides of the Zen range and some 22 miles west of Kumbhi and Gandoi the characteristic red clays and concretionary standstones of the Lower Siwalik rest directly on the Khirthars. An outlying patch of both the marine as well as the fresh-water stage occurs at Bibinani near Quetta. To the eastward of Dera Bugti it thins out. North of the Sihaf plain the series dies out a few miles west of Singsila. Both north and south of the Kahán plain the Upper Nári beds are exposed, though on the southern side they are mostly concealed by the Upper Siwaliks. They die out near the town of Kahán. From Gandoi the series extends to the eastward, bending round to the north and throwing out a few outlying patches connecting it with a large outlier between Gandahari hill and the Sham plateau, where the series perhaps attains its maximum thickness of 1,000 feet. The main outcrop continues uninterruptedly to some distance north of the latitude of Dera Ghazi Khan where Blanford had observed these beds and mapped them as Upper Nári, but had failed to recognize their identity with the ossiferous beds of Dera Bugti. Still further north, LaTouche, examining the Sherani hills near Dera Ismail Khan, found no trace of these Nári sandstones between the Lower Siwaliks and the Khirthars. Mr. G. H. Tipper, however, during a hurried visit to the same area, recognized a representative of the marine brown limestone resting on the Khirthars.

**Absence of Lower Siwaliks at Gandahari.**

It is an important fact that in the large area mentioned above between Gandahari hill and the Sham plateau, where the Nári series is very thick, there is no trace of Lower Siwalik in contact with them, although there is good

evidence at Gujru and elsewhere of the unconformable deposition on them of the Upper Siwalik boulder bed. It is evident, therefore, that during the Lower Siwalik period, at all events, and probably for some time previous, deposition stopped over this area. No marine deposits are found, and the country may have existed as high ground, a theory which is supported by the fact that the beds are certainly much more greatly disturbed than I have noticed to be the case elsewhere.

**Stratigraphical unconformity between Upper Nári and Lower Siwaliks.**

It is clear, therefore, merely from the local stratigraphical evidence as stated above that there is an unconformity between this series and the Lower Siwaliks.

South of Dera Bugti at the top of the series, above the coarse sandstones and immediately below the Lower Siwalik clays, occurs a sandy limestone or sandstone often variegated with ferruginous bandings. This bed would have suggested nothing to me if I had not seen the country near Sehwan in Lower Sind, which I shall now briefly refer to.

**Section at Bhagothoro in Lower Sind.**

Near Bhagothoro, some 16 miles south of Sehwan, occurs a series of beds mapped as Upper Nári by Blanford, and undoubtedly exhibiting only a slightly different facies of the typical Nári sandstone of Sind. These beds correspond lithologically almost exactly with the Nári series, which I have just been describing in Baluchistán, though no trace of a vertebrate fossil has been found in them, any more than in the Nári sandstones throughout Sind. But one harder band of calcareous grit near the top contains marine fossils of a Gaj type and above this occurs the sandy variegated limestone which I have mentioned above, only here containing *Placenta* sp. and the typical Gaj fossils *Ostrea angulata*, Sow., and *O. latimarginata*, Vred. A few other oyster beds lie above this, and immediately above them are the typical Lower Siwaliks, with clays and concretionary bone conglomerates.

**Possibility of a marine stage at the top of the Nári in the Bugti hills.**

In the Bugti country no marine fossils are known with certainty to occur here, but Blanford mentions estuarine species at about this horizon, and at Iliasi I myself found a cast of a shell which is quite different from *Paludina bugtica*, Blanf., and may be a

*Natica.* This bed overlaps all the others beneath it, and is itself overlapped by the Lower Siwalik. It seems, therefore, very probable that here, as has been shown to be the case in Sind, the freshwater conditions of the Upper Nári were followed by a marine transgression. In most of Sind the conspicuous Gaj stage follows, accounting for a thickness of some 1,500 feet. This is scarcely represented either at Bhagothoro or in the Bugti hills, and may have been deposited in neither area.

**Age of the Bugti bone beds.**

This section at Bhagothoro also makes it certain that the series we have just been considering in Baluchistán represents in the main the Upper Nári of Sind, and stops short at least at the beginning of the Gaj, so that we may safely speak of it as aquitanian.

**The Upper Nári series of Sind.**

The Upper Nári series of Sind reaches a thickness of 4,000 to 5,000 feet. Many of its beds are variegated sands, coarse gritty sandstones with ferruginous bands and conglomerates very similar to the beds in the Bugti hills, but the mass of it consists of a grey rather soft sandstone with brown pale ferruginous markings. Beds of this character occur in the Bugti hills at the base of the series, but it is in the greater thickness of these sandstones that the typical Sind area differs from Bhagothoro and Baluchistán. A gradual passage is traced from the Lower Nári (stampian) brown limestones into the freshwater sands, beds containing *Nummulites intermedius* being found 500 feet above the base of the sandstones.

The series passes upward gradually into the marine Gaj.

These beds in Sind have proved entirely destitute of vertebrate remains, the only fossils noticed being obscure plant impressions.

**Fauna of the Upper Nári series.**

The following is a list of the species which comprise the fauna of the Upper Nári freshwater series. As has been stated, the series in Sind is unfossiliferous; therefore the occurrence of these fossils is at present confined to Baluchistán.

The invertebrates have already been described by Blanford[1] with the exception of one new species of *Unio*. It has been

[1] *Mem., Geol. Surv Ind.*, XX, p 129, 1883.

thought better to delay the publication of full descriptions of the vertebrates, as the *Rhinocerotidæ* have not been fully examined and drawings of all of them have yet to be executed. These will, therefore, appear later. In this paper I shall only indicate briefly the affinities to and distinctions from the nearest known species.

## Mollusca.

*Melania pseudepiscopalis* Blanf.
*Melania gradata* Blanf.
*Paludina bugtica* Blanf.
*Unio vicaryi* Blanf.
*Unio cardiiformis* Blanf.
*Unio cardiiformis* var. Blanf.
*Unio cardita* Blanf.
*Unio pugiunculus* Blanf.
*Unio* n. sp.

## Reptilia.

*Crocodilus bugtiensis* n. sp.
*Crocodilus náricus* n. sp.
*Garialis curvirostris* Lyd. n. var.
Chelonian remains, various.

## Artiodactyla.

*Anthracotherium bugtiense* Pilg.
*Anthracotherium mus* n. sp.
*Brachyodus hyopotamoides* Lyd.
*Brachyodus giganteus* Lyd.
*Brachyodus bugtiensis* Pilg.
*Brachyodus longidentatus* n. sp.
*Ancodus ramsayi* n. sp.
*Hemimeryx speciosus* n. sp.
*Telmatodon bugtiensis* Pilg.
*Gonotelma shahbazi* n. gen. n. sp.
*Chæromeryx grandis* n. sp.
*Bugtitherium grandincisivum* n. gen. n. sp.
*Palæochærus affinis* n. sp
*Prodremotherium* sp.
*Progiraffa exiguus* n. gen. n. sp.

## Perissodactyla.

*Macrotherium náricum* n. sp.
*Aceratherium blanfordi* Lyd.
*Rhinoceros sivalensis* var. *gajensis* Lyd.
*Rhinoceros sivalensis* var. *intermedius* Lyd.
*Rhinoceros* sp. aff. *perimensis*.
*Rhinoceros* n. subgenus.
*Amynodon* sp.

## Proboscidea.

*Dinotherium náricum* n. sp.
*Tetrabelodon crepusculi* n. sp.

## Carnivora.

*Pterodon bugtiensis* n. sp.
*Pterodon* sp.
*Amphicyon* cf. *major* Blainv.
*Cephalogale shahbazi* n. sp.

*Crocodilus bugtiensis.*—This species undoubtedly comes nearest to *C. palæindicus* amongst described species. The expansion at the 9th tooth is even greater than it is in *C. palæindicus*. It differs from that species by the extraordinarily nodose sculpture, especially in front of the orbits and on the nasals.

*Crocodilus náricus.*—The surface of the cranium of this species seems to be quite without the nodose irregularities of *C. bugtiensis*. It approaches *C. palustris*, but is easily distinguished, (1) by the greater width of the interorbital bar, (2) by the rapid narrowing of the cranium in front of the orbits, (3) by the small size of the supratemporal vacuities.

*Garialis curvirostris* Lyd. n. var.—Amongst the Bugti collections are numerous specimens of the cranial rostra, in which the maximum diameter of the premaxillaries varies from 75 mm. up to 160 mm. The smaller ones seem only to differ from *G. curvirostris* type by the slightly greater expansion of the premaxillaries and a greater interval between the 2nd and 3rd teeth. The amount of the upward curvature varies, as also does the relative expansion of the premaxillaries. The larger forms approach

*G. pachyrhyncus* Lyd. although the premaxillaries are never expanded to the extent that they are in that species. It is probably to be regarded as the ancestor of both *G. curvirostris* type and *G. pachyrhyncus.* All the specimens show the absence of a connection between the nasals and the premaxillaries, which character settles the generic position of the species. It is noteworthy, however, that a fine specimen of a mandible indicates that this Garial possessed 18 teeth, 14 of them being in the symphysis. This small number of teeth shows an approximation to *Tonistoma,* but there is no enlargement of the 9th tooth, as is the case in that genus.

*Anthracotherium bugtiense.*—Further material belonging to this species has been obtained, amongst it being a very large mandible showing that this *Anthracotherium* must have attained an enormous size, exceeding that of other known species.

*Anthracotherium mus.*—This species is represented by a mandible. It is smaller than *A. silistrense* and differs in the lesser development of the outer cingulum.

*Brachyodus giganteus* Lyd. and *Brachyodus hyopotamoides* Lyd.—The fairly extensive material at my disposal has enabled me to confirm Lydekker's creation of two species to receive certain upper teeth and mandibles of equal size and showing such resemblances as to lead many palæontologists to call into question the correctness of their separation. I have, however, found myself unable to refer either of them to the genus *Anthracotherium,* both on account of the less rounded nature of the columns of the upper molars, the less complete separation of the mesostyle, and the shorter mandible having the four premolars close together and a diastema between them and the canine. The following characters will afford a diagnosis of the two species.

*Brachyodus giganteus* runs to a greater size than *B. hyopotamoides.* Cranium high and broad, flat over the nasals. Upper molars much broader than long, with a protostyle pronounced, but compressed antero-posteriorly. Mandible very deep and massive but short, with molars broader in proportion to their length than in *B. hyopotamoides.* Talon of last lower molar with a single cusp. Lower canine elongate-oval in cross section.

*Brachyodus hyopotamoides.*—Cranium low and elongated, rounded over the nasals. Upper molars scarcely broader than long.

Protostyle not compressed antero-posteriorly. Mandible shallow and rather slender with molars relatively longer than in *B. giganteus*. Talon of last lower molar with a double cusp. Lower canine circular in cross section.

*Brachyodus bugtiensis.*—The mandible figured in *Rec., Geol. Surv. Ind.*, XXXVI, part 1, p. 45, under the name *Telmatodon bugtiensis*, must now be considered as that of a *Brachyodus*. Rather better mandibles have come to hand, but no upper teeth (see also page 152).

*Brachyodus longidentatus* is smaller than *B. giganteus* and *B. hyopotamoides* and also than *B. onoideus* Gervais. The 5th cusp is well indicated and a clearly defined series of wavy striæ adorns the whole surface. It is distinguished from all other species of *Brachyodus* by the teeth being much longer than broad. A broad cingulum surrounds both upper and lower molars. The mandible is short and slight. The four premolars are close together and there is a diastema behind the canine. The lower molars have sharp cusps and are rather more hypsodont than is usual in the genus. The talon of the last lower molar has a single cusp.

*Ancodus ramsayi.*—A mandible having rather hypsodont teeth with perfectly smooth enamel, broad transverse valleys, sharp V-shaped outer crescents, and prominent posterior cusp to the last premolar is referred to this genus. It may be compared with *A. bovinus* Owen though decidedly differing from that species, by the relatively narrower teeth, by the much broader cingulum, especially anteriorly, and by the complete absence of any sculpture on the enamel.

*Hemimeryx speciosus.*—The upper molars of this species exhibit resemblances to *Hemimeryx blanfordi* Lyd. from the Lower Siwaliks of Sind and to a small tooth from Kushálghar, in the Punjab, described by Lydekker under the name *Merycopotamus pusillus*.

In all three species the transverse valley is more or less open, there is no trace of a 5th tubercle and a prominent cingulum exists on all sides of the teeth.

It seems likely that they should all be referred to the same genus. Neither of them agrees entirely with the type species of *Merycopotamus* either in the open character of the transverse

valley or in the folding of the protostyle, mesostyle and parastyle over the outer surface of the protocone and metacone. *Merycopotamus pusillus* approaches it most nearly in the former respect and *Hemimeryx blanfordi* in the latter. This species differs from *Merycopomatus* in both particulars.

The mandible is slender and has a very pronounced groove on its under side beginning under the last molar and extending back to the angle. There is a deep descending flange as in *Merycopotamus dissmilis.* The talon of the last lower molar has a single cusp. A prominent cingulum is present and the surface of the teeth is decorated with wavy striæ. The present species is slightly larger than *Merycopotamus pusillus* and much smaller than *Hemimeryx blanfordi.*

*Telmatodon bugtiensis.*—Further material has convinced me that the mandible referred provisionally to this species in *Rec., Geol. Surv. Ind.,* XXXVI, part 1, p. 54, is not only too small to be associated with the upper molars of *T. bugtiensis,* but differs from them in the nature of the sculpture on the enamel (see also page 151). It may be remarked that the weathering of these specimens may give one a totally false impression as to the character of the sculpture, if the number of specimens is small.

In my collection are several mandibles which are rather bunodont, very slender and elongated, with long premolars in a continuous series and canines circular in cross section with a diastema behind them. These show a sculpturing of the enamel which exactly agrees with that on unweathered upper molars of *Telmatodon bugtiensis.* They also correspond in size to the upper molars and may reasonably be placed here. The mandible erroneously referred to *Telmatodon* is now considered to be a species of *Brachyodus*—*cf.* p. 151.

*Gonotelma shahbazi.*—The upper molar on which this new genus is founded exhibits characters which approximate to those of *Telmatodon.* It is very much smaller, being 22 mm. in length and 23 in breadth. Whereas the 5th tubercle in *Telmatodon* is hardly at all indicated, in the present tooth it is very distinct though small. The outward slope of the inner surface of the inner columns is less than in *Telmatodon.* The cingulum is more prominent and passes round to the inside of the tooth. Two or

three tubercles are present at the entrance to the transverse valley.

A mandible almost certainly belongs to this species.

*Chœromeryx grandis.*—This species is larger than *C. sindiense* Lyd., but is otherwise very near to it. The median external loop is more prominent and the external cingulum better marked in the Bugti species.

A very distinct resemblance is also noticeable to some specimens of *Hyoboops palæindicus.*

*Bugtitherium grandincisivum.*—The present genus is founded upon two fragments of the skull, one of which was referred to in *Rec., Geol. Surv. Ind.*, XXXVI, part 1, p. 45. They are both identical and embrace portions of the maxillaries and premaxillaries. They are figured in Plates 2 and 3. On both of them the crowns of the teeth are absent. I have however found several isolated teeth, incisiform in shape, with large roots, which may be referred with reasonable probability to this species. The larger fragment is 329 mm. long and extends back to the alveolus of the 3rd premolar. The face must have been extraordinarily elongated, mainly due to the large size of the incisors, because the diastema between the canine and the 1st incisor is not great, and behind the canine the teeth succeed each other in continuous order. The suture between the maxillary and premaxillary is well shown and enables us to differentiate the teeth. The 1st incisors are enormous. Their alveoli measure 38 mm. in diameter, but they were not excessively deep-rooted considering their size. The alveoli of the 2nd incisors measure 45 mm. in diameter. Their roots were long and curved and extended back almost as far as the canine. I have isolated teeth of which the diameter of the root is 55 mm. The 3rd incisor is small. The diameter of its alveolus is about 25 mm. The canine was either double-rooted or the root was so excessively constricted as practically to be termed so. The long diameter of its alveolus is 43 mm. and the short diameter 24 mm.

The 2nd and 3rd incisors and the canine are almost in one line, the diameter of this portion of the skull being very slightly greater opposite the 2nd incisor. Its breadth at the 2nd incisor is 152 mm. Behind the canine the palate contracts, and

the remaining teeth lie almost entirely within the inner edge of the canine. The following are the dimensions of their alveoli :—

| | Length. | Breadth. |
|---|---|---|
| 1st premolar . . . . . | 49 mm. | 24 mm. |
| 2nd do. . . . . . | 46 „ | 24 „ |

The tip of the snout has a strong protuberance above and between the front incisors. The distance between the tip of the snout and the anterior palatine foramen is about 100 mm. The premaxillary crest ascends only very slightly and there was evidently a free surface for some distance posteriorly, so that the nasals did not articulate with the premaxillaries and perhaps only slightly with the maxillaries. Remains of the palatine process are visible from below, dividing the anterior palatine foramen into two parts. The palate narrows as far as the 3rd premolar; behind this it probably expands again. From the anterior palatine foramen two ridges run backward on either side of the palate. On the outer side of each ridge is a deep groove which terminates opposite the 2nd premolar in a clearly defined foramen. Opposite the 3rd premolar is another smaller foramen. Of fairly frequent occurrence are examples of a large incisiform tooth, of a size corresponding exactly to the alveolus of the 2nd incisor tooth in the skull described above. It is somewhat anthracotheroid in general character, but as the largest species of *Anthracotherium* does not possess incisor teeth at all approaching these in size, and as nothing else has been found in the Bugti hills with which these teeth could be associated, it is almost certain that they are to be referred to the same species as the skulls of *Bugtitherium*. The tooth is longer than broad, sub-conical, and broadly speaking trigonal in shape, though the external angle is well-rounded. It points forward and outward so that the posterior edge is as much as 40° inclined to the vertical. On the inner side it is girdled at the base of the crown by a strong crenulated cingulum, which does not extend to the external side, but culminates posteriorly in a prominent tubercle and anteriorly in another tubercle situated on an almost flat and horizontal area which bulges out from the antero-internal corner of the tooth. Two well-marked ridges run in front and behind the tooth from the apex to the base. The plane of these ridges does not divide the tooth into two symmetrical portions. The external portion is much the larger and is

strongly convex. The internal portion is much the smaller and is only very slightly convex. The posterior ridge terminates in a prominent tubercle a short distance below and on the inner side of the posterior cingular tubercle, while the anterior ridge dies away on the protuberant antero-internal area mentioned above.

There are some broad somewhat obscure puckers in the enamel, running down vertically from base to apex—about 6 or 7 on the outside and 2 or 3 on the inside of the tooth. Beyond these the enamel is perfectly smooth and unsculptured and is only scored by the numerous concentric lines which are to be observed on many teeth and are specially noticeable in the case of the Rhinocerotid family.

The following are the dimensions of the specimen figured in Plate 3, fig. 1 :—

| | |
|---|---|
| Height . . . . . . . . . | 67 mm. |
| Maximum diameter . . . . . . | 58 ,, |
| Minimum do. . . . . . . . | 42 ,, |

The foregoing description and the plates will I hope enable the characters of these specimens to be understood. They clearly represent something new, but beyond stating that their affinities are distinctly suine and possibly anthracotheroid, as evidenced by the peculiar incisors and the conformation of the palate, it would be premature on such slender material to do more than name them with the hope that at some future time sufficient material will be found to enable us to classify the genus more exactly.

*Palæochærus affinis.*—A maxilla with $m^1$ and $p^4$ is all of this species that I possess. It seems very near to *Hyotherium perimense* Lyd. corresponding precisely in size and shape with that species. The Bugti species apparently differs in the greater development of the accessory tubercles and the cingulum.

*Prodremotherium* sp.—A mandible containing the last two molars appears to resemble nothing else so much as *Prodremotherium.*

*Progiraffa exiguus.*—A mandible containing the last two molars seems to find no place in any existing genus. The dimensions of $m_3$ are as follows :—

length 28 mm., breadth 13 mm.

It is not Palæomerycine, because (1) there is no Palæomeryx-fold on the posterior side of the anterior crescents; (2) the costæ on the two internal crescents are very slight compared with *Palæomeryx*, especially the posterior one which is rounded, more

like the pigs; (3) they are narrower teeth than those of *Palæomeryx*. On account of its brachyodont nature it cannot be compared with Schlosser's genus *Cervavus*.

It bears great resemblance to the giraffe; there are small tubercles in the median valleys, and there is a cingulum on the front base of both molars. The talon shows very distinctly a division into two lobes, the outer crescent having a distinct costa on its internal side, while the external crescent is represented by a small tubercle. Between the two is a cavity. The front horn of the crescent is however much less bent than in *Giraffa*. It meets the crescent just in front of it half way between the edge of the V and the end of the lobe. The breadth of the teeth is also less. The rugose character of the sculpture is almost exactly like that of *Giraffa*.

*Macrotherium náricum*.—Remains of this species are numerous. It differs like *M. grande* and probably *Chalicotherium sivalense* from *Chalicotherium goldfussi* and *antiquum* by having no re-entrant fold of enamel on the antero-external angle of the upper molars. In *Chalicotherium sivalense* the posterior ridge connecting the metacone and hypocone is only very faintly shown. In the Bugti species as in *M. grande* it is pronounced. In neither *M. náricum* nor *M. grande* does the antero-external angle overlap the tooth next in front. This overlapping is very noticeable in *C. sivalense* and the other species.

The Bugti species differs from *M. grande* by its more elongated upper teeth, by the approximate equality in size of $m^1$ and $\underline{m^2}$ and by the much slighter indication of a median denticule. In *M. grande* $m^1$ is much smaller than $m^2$ and the median denticule is easily traced. It is however undoubtedly closely allied to the Bugti species.

The *Rhinocerotidæ* have not been fully examined, but an interesting feature in them is the indication of the existence of ancient types in those beds. One upper molar has the posterior loph incomplete, the hypocone being quite distinct and only separated by a low ridge from the metacone. This is a feature which I have never seen in any Rhinocerotid molar, and which entitles it at all events to sub-generic distinction.

*Dinotherium náricum*.—Of this species we possess the last lower true molar, the 3rd lower milk molar, the 2nd upper milk molar and the 2nd upper true molar,

It differs very markedly from the other known species. In size it corresponds nearly with *Dinotherium indicum* var. *pentapotamiæ* Falc. The last lower molar differs both from *D. indicum* and *D. giganteum* by the fact of the ridges not being parallel to one another, but diverging from without inwards. Also the outer portion of the valley falls very abruptly from the longitudinal ridge and there is a well-marked crenulated cingulum at the inner entrance of the transverse valley. The 2nd upper milk molar possesses a prominent tubercle at the outer entrance of the transverse valley and a smaller one at the inner entrance. The only specimen of *D sindiense* Lyd. is so battered as to render any comparison with the teeth impossible. The species was founded solely on the shape of the mandible. Consequently, beyond the fact that the present specimens indicate a larger species, nothing further can be said.

*Tetrabelodon crepusculi.*—The mastodon teeth contained in my collection are those of a trilophodont species, undoubtedly nearer to *Mastodon falconeri* Lyd. than to anything else. It differs unmistakeably from that species in the far more open nature of the valleys, which are not blocked by accessory columns, by the simpler talon and by the more prominent cingulum on all sides of the teeth. To this species is referred a maxilla with a small slightly worn tooth 58 mm. long preceded by a much worn tooth 34 mm. long and by an empty alveolus. I see no sign of premolars to succeed them, but all the same it is not unlikely that they are milk teeth, which from their size and general character they might well be.

*Pterodon bugtiensis.*—This species is founded on a mandible containing the last two molars and showing the alveoli of the last premolar and the first molar.

The length of $m_3$ is 54 mm. and that of $m_2$ 42 mm. It will thus be seen that it is immensely bigger than any hitherto known species of *Pterodon*. The teeth however so nearly resemble in structure those of *P. dasyuroides* Blainv. and *P. africanus* Andrews, that its generic position seems hardly doubtful.

Apart from its size—twice that of *P. africanus* Andr.—it differs from other species by the larger size of $m_3$ relative to $m_2$, by the greater breadth of the teeth and the more pronounced cingulum.

*Pterodon* sp.—A maxilla with $\overline{m^2}$ and $\overline{m^3}$ and a last lower premolar find a place here. They belonged to a much smaller animal than *P. bugtiensis*, the length of $\overline{m^2}$ being 34 mm. They are only slightly inferior in size to the corresponding teeth of *P. africanus*, but in form $\underline{m^2}$ seems rather to approach *P. biincisivus* Filhd. The occurrence of the genus *Pterodon* in these beds is interesting as it has not hitherto been recorded in beds newer than upper Eocene (bartonian) from France, Switzerland, the Hampshire basin and Northern Africa.

*Amphicyon* cf. *major* Blainv.—The tubercular upper tooth, which represents the species, shows me no characters by which I can distinguish it from the figures of specimens from Sansan figured by Blainville.[1]

*Cephalogale shahbazi.*—The characters of the whole mandible are shown by the specimens in my hands.

It was a species of immense size and having a very massive jaw. The length of $\overline{p_4}$ is 21·5 mm. and that of $\overline{m_1}$ 30 mm., while the depth of jaw below the first molar is 65 mm.

It presents affinities to a number of species which have been referred by Schlosser either to the genera *Cephalogale* or *Pachycynodon*. Certain of these are considered by Schlosser as passage links between the two genera and the Bugti species seems to stand in such a position. In the depth of jaw it approaches *Pachycynodon*. In the slightly developed posterior tubercle of $p_4$ it is nearer *Cephalogale geoffroyi* and *minor*. In *Pachycynodon* the inner cusp of the carnassial is distinctly separated from the principal one, in which respect the Bugti species differs and is nearer to *Cephalogale geoffroyi* and *robusta*.

**Palæontological evidence as to the age of the Upper Nári.**

On comparing this fauna with that of the Lower Siwaliks, of which a list is given on pp. 161-162, one does not find a single absolute identity. The two species, *Rhinoceros sivalensis* and *Garialis curvirostris*, which are common to them, possess varietal differences in the two formations, and one of them is a reptile, and therefore of less value for determining the horizon. On the other hand the Anthracotheroids, which constitute such a marked feature of the Nári fauna, have almost entirely vanished from the scene by Lower Siwalik times. Thus the palæontological no less than the strati-

[1] Blainville, Ost. Suburaus, Pl. XIV.

graphical evidence points to a great time-break between the two series.

Although *Amphicyon major*, which seems to be identical with, and *Macrotherium grande*, which comes near to, Bugti species, occur in late burdigalian, their evidence is largely discounted by the presence of *Anthracotherium bugtiense*, which is closely allied to the large species from the stampian of Europe, and of ancient genera like *Pterodon* and *Ancodus*. *Brachyodus*, which seems, after the *Rhinocerotidæ*, to dominate the formation, is a typically upper aquitanian genus.

On the whole, therefore, we can say that the vertebrates do not contradict other evidence in assigning this freshwater formation to the aquitanian.

## THE LOWER SIWALIKS.

### The Lower Siwaliks of the Bugti Hills.

The Lower Siwalik series in the Bugti hills is generally from 1,000 to 1,500 feet in thickness. It is sometimes difficult to draw the line between it and the Upper Siwaliks, as the one series often succeeds the other without any unconformity of dip. The most convenient distinction to draw, however, and one which probably has a deeper significance apart from the mere lithological fact, is that, in the Lower Siwalik sandstones and conglomerates, nummulitic limestone pebbles are almost invariably absent, contrary to what is the case in the upper series. It is to be inferred from this that much of the nummulitic limestone was covered by other deposits during the Lower Siwalik period. Subsequently disturbance of the land area took place and extensive erosion followed, laying bare the limestone hills to contribute to the Upper Siwalik boulder deposits.

**Lithological character of the Lower Siwaliks.**

The base of the series everywhere seems to be characterized by red or grey clays intercalated with which are soft, grey, brittle, well-bedded sandstones amongst which occur bone conglomerates. These conglomerates are amongst the most characteristic beds in the series. They seem to be largely concretionary and contain pellets of red clay and calcareous matter with occasionally small ferruginous nodules in a sandy matrix. Actual pebbles, which are not frequent, are invariably

of sandstone. They occur very frequently and from their superior hardness give rise to a series of scarps. These concretionary conglomerates continue to occur as lenticular beds in the next higher member of the series,—a massive sandstone, in which calcareous segregation has taken place to such an extent as to make Dr. W. T. Blanford's name for it of "pseudo-conglomerate" a very appropriate one. These calcareous concretions are sometimes several feet in diameter and are often of a red colour, thus showing up distinctly in the midst of the lighter coloured matrix. In some places the calcareous matter is so abundant that the rock may fitly be called a limestone. This "pseudo-conglomeratic sandstone" weathers, as might naturally be expected, in a characteristic columnar and nodular fashion.

In some cases, as Dr. Blanford observes, there seems to have been contemporaneous erosion of the red clays, which have been rolled and re-deposited in a sandstone matrix of a different colour.

Above these occur a greater or less thickness of characteristic fine-textured grey sandstones containing numerous black grains of hornblende, with never a trace of a pebble. The Lower Siwalik sandstones may readily be distinguished from those of the Nári series by their much finer character, their freedom from quartz pebbles, and by the absence of ferruginous matter.

**Distribution of the Lower Siwaliks.**

In the Marri country between Kahan and Sibi, the Lower Siwalik beds are characterized throughout by a red colour, pseudo-conglomerates as well as sandstones and clays. As a general rule, wherever the Nári series is exposed, the Lower Siwaliks are found overlying them with a perfectly conformable dip; in the absence of the Náris the Lower Siwaliks rest on the Khirthars.

An exception to this has been noted above in the case of the Gujru outlier. Further north at Pishini a very thin representative, 100 feet at most, of the Lower Siwaliks occurs between the Upper Siwaliks and the Náris; its character could not be well ascertained through the outcrop being obscured by sub-recent deposits. The series doubtless extends further north into the Bannu and Kohat districts, where it is probably represented by some portion of the great freshwater formation there mapped by Wynne and others.

It also appears to be found in other parts of Baluchistán.

**"Middle Siwaliks."**

Here, besides attaining an immensely greater thickness, it probably includes higher beds deposited between the Lower and Upper Siwaliks, which may be known as Middle Siwaliks. Near Quetta, according to Mr. Vredenburg, the thickness of the whole Siwalik series cannot be far short of 10,000 feet, of which only the smaller portion must be Upper Siwalik.

Fossil vertebrate remains, chiefly of Crocodiles, Chelonians, Proboscidians and Rhinocerotids, occur in the basal concretionary conglomerates, but they are always fragmentary and isolated.

I have recognised in the Bugti hills *Tetrabelodon angustidens* var. *palæindicus* Lyd., *T. falconeri* Lyd., *T. pandionis* F. and *Dinotherium indicum* var. *pentapotamiæ* F.

## Lower Siwaliks of Sind.

The character of the series in Lower Sind is almost identical with that of the Bugti hills. The bone beds at the base are rather more true conglomerates. West of Sehwan they cannot be much more than 1,500 feet thick and thin out still more to the southward, but in Northern Sind they are much thicker than in the Bugti hills, and here also "Middle Siwaliks" are doubtless represented.

**Vertebrate fauna of the Lower Siwaliks.**

The following is a list of the species known with certainty to occur in the Lower Siwaliks of Baluchistán and Sind. No mollusca have been identified with certainty from these beds. Near Quetta at the base of the series Mr. Vredenburg found a *Melania*, certainly different from the two species of *Melania* from the Upper Nári described by Blanford but in too poor a state of preservation to permit of identification.

I have examined the specimens in the Indian Museum, and removed, as far as possible, the doubtful species from the previous lists, at the same time revising names and making additions in the light of our subsequent knowledge.

### Reptilia.

*Crocodilus palæindicus* F.
*Garialis pachyrhyncus* Lyd
*Garialis curvirostris* Lyd.

## Artiodactyla.

*Anthracotherium silistrense* Pentland.
*Hemimeryx blanfordi* Lyd.
*Agriochœrus* sp.
*Chœromeryx sindiense* Lyd.
*Hyoboops palæindicum* Lyd.
*Palæochœrus sindiensis* Lyd.
*Listriodon* sp.
*Sus hysudricus* F. & C. var.
*Dorcatherium majus* Lyd.
*Dorcatherium minus* Lyd.
*Progiraffa* sp.

## Perissodactyla.

*Chalicotherium sindiense* Lyd.
*Rhinoceros sivalensis* F. & C. var.
*Aceratherium perimense* F. & C.

## Proboscidea.

*Dinotherium indicum* F. type sp.
*Dinotherium indicum* var. *pentapotamiæ*.
*Dinotherium sindiense* Lyd.
*Tetrabelodon angustidens* Cuv. var. *palæindicus* Lyd.
*Tetrabelodon pandionis* F.
*Tetrabelodon falconeri* Lyd.
*Mastodon perimensis* C. & C.
*Mastodon latidens* Clift.

## Carnivora.

*Amphicyon* sp. (*palæindicus?*).

*Hyoboops palæindicus.*—This species was originally described by Lydekker [1] under the name *Hyopotamus palæindicus*. He remarked that it was an aberrant form of the genus, and as Madame Marie Pavlow has since pointed out [2] the species does not show the typical generic characters of either *Brachyodus* or *Ancodus*. The 5th cusp is feebly represented, the protocone is very much weakened, and the tooth in general is much less bunodont. M. Trouessart [3] has suggested for it the name *Hyoboops* which

[1] *Pal. Ind.*, Ser. X, II, p. 158.
[2] *Bull. Soc. Imp. Nat. Moscow*, XIV, p. 287 (1900).
[3] *Catalogus Mammalium* Suppl., 1904, p. 651.

I shall adopt. At the same time I consider it very doubtful if the genus can be maintained distinct from *Chœromeryx.*

*Palæochœrus sindiensis.*—Following Stehlin, I have altered the generic designation of this species from *Hyotherium.*

*Listriodon* sp.—Stehlin[1] has pointed out that the premolars figured by Lydekker in *Pal. Ind.* under the name *Hyotherium sindiense* are really those of *Listriodon*, which an examination of the specimen leads me to confirm. It should be added that in *Rec., Geol. Surv. Ind.*, IX, p. 94, Lydekker mentions the occurrence of *Listriodon* in Sind.

*Sus hysudricus* var.—The Sind specimens are much smaller than the type.

*Progiraffa* sp.—Lydekker[2] mentions a poorly preserved lower molar from Sind and refers it provisionally to the genus *Palæomeryx*. It has no Palæomeryx fold however and the resemblance to the corresponding tooth of the Bugti genus is so great that I must place it in the same genus.

Under the name *Chalicotherium sindiense* I include the ungual phalange described by Lydekker[3] first under the name *Manis sindiensis* and then under that of *Macrotherium sindiense* and some lower molars, probably the ones referred to by Lydekker in *Rec., Geol. Surv. Ind.*, IX, p. 91.

Lydekker in 1876 remarked on the older facies of the Sind fauna as compared with that of the Punjab and the Dun area (*Rec., Geol. Surv. Ind.*, IX, p. 94), and looking at it in the light of our additional knowledge I see more reason than ever to agree with the statement.

**Age of the Lower Siwalik vertebrate fauna of Baluchistán and Sind.**

Having separated off the Nári vertebrate fauna of the Bugtis, the L. Siwalik fauna of Sind and Baluchistán is the oldest of what remains, with the exception of a small fauna obtained from Kushálghar on the Indus which may possibly be slightly older. It is hoped that a prospective tour in that area will enable the writer to settle that and other points relating to the ossiferous beds of the Punjab.

In the first place the three Crocodilian species are confined to the Sind fauna, while *Garialis gangeticus*, *Crocodilus palustris* and

[1] *Abh. Schw. Pal. Gesells.*, pt. 1, 1899.
[2] *Pal. Ind.*, Ser. X, Vol. I, xvii.
[3] *Pal. Ind.*, Ser. X, I, p. 82, & IV, p. 50.

others of the newer species found in the Punjab and Dun area are absent from Sind. Although some of the Sind mammalian species also recur in the Punjab, they are invariably the more ancient types such as the *Dinotheridæ*, *Tetrabelodon*, *Listriodon*, *Amphicyon* and *Anthracotherum silistrense.* Some of the others differ varietally from the Punjab forms. On the other hand *Hipparion* and the numerous members of the Giraffe family, so characteristic both of the Punjab and of the original Siwalik area, are unrepresented. Their place is taken by selenodont pigs, of which *Merycopotamus* is the only genus met with in the newer Siwaliks, this particular genus not occurring in Sind. The recent discoveries in the Nári beds of the Bugti hills shed fresh light on the unique genera *Hemimeryx*, *Chœromeryx* and *Hyoboops* and so enable us to deduce important evidence on the question at issue. For it is now clear that we must search for their affinities in an older rather than a newer epoch. Hence their presence here increases the faunistic gap between the Lower Siwaliks of Sind and the fossiliferous Siwaliks of the Punjab. A like value attaches to the occurrence of *Palæochœrus* and *Progiraffa* here as well as in the Náris. All that has been said about the Siwalik fauna of the Punjab and the Duns applies equally to the faunas of Pikermi and Samos. One cannot help being struck by the older facies of the Sind fauna. Since the Pikermi deposits are pontian in age, the lowest Siwaliks must be older than that.

*Tetrabelodon angustidens* ranges in Europe or Africa from burdigalian to sarmatian inclusive. Consequently the evidence of this species will impel us to assign the fauna we have been considering to the sarmatian at latest, while there is a possibility of its being as old as tortonian.

In this connection, it must be borne in mind that it is the fossiliferous basal beds of the Lower Siwaliks that are here classed. The upper beds and the so-called "Middle Siwaliks" may pass into the Pliocene, and it is from this part of the series that the Hipparion fauna is probably derived in other parts of India.

## THE UPPER SIWALIKS.

As has been stated above (p. 159) these beds are sharply distinguished from the Lower Siwaliks by the frequency of

pebbles of nummulitic limestone in the sandstones, grits and conglomerates. In most cases there is a great thickness of boulder beds with limestone fragments bigger than a man's head. Brown sandstones and sandy clays are also very characteristic beds in this division. On the northern edge of the Sihaf plain the boulder beds are well developed; also in the Kahan plain and elsewhere, where the boulder débris conceals all other formations from view. South of Gandoi the series is well developed, going towards Jacobabad. They generally dip perfectly conformably to the Lower Siwaliks, but north of Kalakhu some 500 feet of them are exposed resting on the upturned edges of the Lower Siwaliks, while in the Gujru and Sham area they are found in many places either overlying the Nári sandstones or Khirthars directly or with only a small thickness of Lower Siwalik intervening. There must therefore be a very considerable unconformity and time-break between the Lower and Upper Siwaliks, especially when it is remembered that in other parts of Baluchistán and Sind the same beds are separated from the base of the Lower Siwaliks by an extra 4,000 or 5,000 feet of "Middle Siwalik," which is unrepresented in the Bugti hills.

**Unconformity of Upper Siwaliks to older beds.**

In the Bugti country they are rarely more than 500 feet in thickness, but in the Marri hills east of Sibi they are 2,000 feet or more thick, and these thicknesses are probably exceeded in other parts of Baluchistán and in Sind, where Blanford estimated their thickness as approximately 5,000 feet. They are absolutely unfossiliferous, but probably correspond to certain fossiliferous beds at the top of the Siwaliks in other parts of India and belong to the upper part of the pliocene.

## POST-TERTIARY DEPOSITS.

Post-Tertiary deposits are met with everywhere about the hills. They are often very similar in appearance to the Upper Siwaliks, but are distinguished by their horizontal bedding. In more than one place I have been able to trace a later pebble-bed resting on tilted Upper Siwaliks where there was no line to be drawn lithologically. Some of these deposits may be pleistocene, and the same is probably true of the ancient Indus alluvium, which extends up on either side of the railway almost as far as Sibi.

Borings or excavations in the future may bring to light a pleistocene fauna of a similar character to that which has been discovered in the older Gangetic alluvium.

## SUMMARY.

The main conclusions arrived at in this paper may be summarized as follows:—

1. The ossiferous formation described by Blanford in the Bugti hills as Lower Siwalik is not a single series, but is divided into two by a distinct unconformity.
2. The older of these two series contains a rich anthracotheroid fauna of aquitanian type associated with a fresh-water molluscan fauna, described by Blanford, which has no affinity whatever to modern types. The newer series contains *Tetrabelodon angustidens* var. *palæindicum* Lyd., *T. pandionis* F., *T. falconeri* Lyd. and *Dinotherium indicum* var. *pentapotamiæ* F.
3. The first-named is identical with the Upper Nári of Sind and is aquitanian in age.
4. The second is truly Lower Siwalik and is identical in character with the Lower Siwalik of Sind. It is older than the deposits of Pikermi and Samos and is at latest sarmatian in age.
5. The Upper Siwaliks are absolutely unconformable to the Lower Siwaliks in the Bugti hills and separated from them in Sind and other parts of Baluchistán by a considerable thickness of strata known as "Middle Siwalik." The Upper Siwaliks are unfossiliferous in this area, but probably correspond to the newest fossiliferous beds of the Siwaliks elsewhere in India and belong to the upper portion of the pliocene.
6. Lying unconformably on all the older beds are horizontally bedded gravels of Post-Tertiary age, many of which are no doubt pleistocene. The same is probably true of the older Indus alluvium.

## LIST OF PLATES.

PLATES 2 and 3. Skull of *Bugtitherium grandincisivum.*

PLATE 4. Incisors of *Bugtitherium grandincisivum.*

# NOTES ON THE GEOLOGY AND MINERAL RESOURCES OF THE RÁJPIPLÁ STATE. BY P. N. BOSE, B. SC. (LOND.), F.G.S. (With Plates 5 and 6.)

## CONTENTS.



## I.—PHYSIOGRAPHY.

**Situation.**

RÁJPIPLÁ, the premier State in the Rewákánthá Agency, is situated between 21° 23′ and 21° 59′ north latitude and between 73° 5′ and 74° 0′ east longitude, and comprises an area of about 1,500 square miles. In 1901 it had a population of 117,175.

**General aspect: hills.**

The State is divided into six talukas—Gardeshwar, Nándod, Bhálod, Dediápárá, Váliá and Jhagadia. The greater portion of the Gardeshwar taluka is a rugged jungle tract north of the Narbada river, about twenty miles east and west, by eight miles north and south. The whole of the Dediápárá taluka and parts of the other talukas form a sparsely populated, forest-clad, hilly upland, the western continuation of the Sátpurá range. The upland is

bounded on the northern and eastern sides by high, craggy, rather sharp-crested ridges. The northern ridge, which may be called the Rájpiplá ridge after the ancient capital of the State, which is situated upon it, runs roughly parallel to the Narbada river. It is loftiest at the eastern end, where one of its peaks (Dháman Mál) rises to a height of nearly 3,000 feet above sea level, and gradually decreases in height and loses in definition south-westward until it merges into the alluvial flat of Guzerat. The eastern ridge is rather an offshoot of the northern one, and being comprised chiefly within the limits of the dependent State of Ságbárá may be called after that place. The forest-clad highland mentioned above has an average height of about 800 feet above sea level at the eastern end in the Dediápárá taluka. It, too, slopes south-westward like the Rájpiplá ridge until it is gradually lost in the undulating plain of the Váliá and Jhaghadia talukas in the western portion of the State.

**Rivers.**

The Narbada river enters the State at Mánkadkháda (28 miles east of Nándod as the crow flies). For about 20 miles it runs in a fairly straight course through a picturesque, well-wooded, hill country, and then merges into the fertile alluvial plain of Guzerat near Gardeshwar, through which it meanders until it falls into the sea near Broach. At places the river is deep and narrow, imprisoned in gorges cut through black trap rock, and elsewhere it broadens into shallows and rapids. Of the rapids, those of Mokhadi have the greatest fall. Notwithstanding the rapids, the river is navigable to the extreme eastern border of the State for small craft of about 25 maunds burden.

The portion of the alluvial flat below Gardeshwar which is included in the Nándod State (Nándod, Bhálod and Jhaghadia talukas) measures about 40 miles in length and 8 in width.

The Deva river, which forms a part of the eastern boundary of the State, joins the Narbada at Sulpán, a rather important place of Hindu pilgrimage. For about 6 miles above its junction, nearly as far as the ruins of Dumkhal, it cuts its way through steep, high, overhanging scarps of sandstone.

The Karjan river drains the central portion of the forest-clad upland mentioned above and falls into the Narbada. Both the Karjan and the Deva run a south-north course, but their tributaries and the other rivers of the State (excluding Vári and

Sagbára)—the Mádhumati, the Bundva, the Káveri, the Umravati, the Kim and the Tarán—run in channels roughly directed east and west. This direction, as will be seen hereafter, coincides roughly with that of the rock strike, and of the trend of the faults, dykes and veins occurring in the area.

## II.—PREVIOUS OBSERVERS.

**Copland, 1819.**

The earliest reference to the geology of the Rájpiplá State is contained in a paper on the well-known carnelian mines of Ratanpur by Dr. J. Copland, of the Bombay Medical Service, published in the Transactions of the Literary Society of Bombay (Vol. I, p. 289, 1819), an extract from which is given in the appendix.

Much of the description given by him still holds good. I did not, however, notice any "fire-damp" mentioned by him, nor did I come across any "mocha" stones.

**Dr. Lush, 1836.**

The next observer was Dr. Lush, who in a paper entitled "Geological Notes on the Northern Concan and a small portion of Guzerat and Kathiawar" (Journal. Asiatic Society of Bengal, Vol. V, p. 761) refers to the carnelian mines of Ratanpur.

**Major Fulljames, 1838, 1852.**

In 1838, Major Fulljames contributed to the Transactions of the Bombay Geographical Society (Vol. II, p. 74) an account of the Ratanpur mines which he had visited in 1832. Later on, in 1852, he submitted "Statistical and Geological Notes" to the Government of Bombay, which were embodied in the "Bombay Selections" (New Series, No. XXIII, pp. 93—114). The Nummulitic rocks in the western portion of the State are referred to in these notes, and mention is made of the slag heaps at Limodra (Jhaghadia taluka).

**W. T. Blanford, 1862-63.**

The first comprehensive account of the geology of the State was published in the Memoirs of the Geological Survey of India (Vol. VI, part 3) in 1869. The Memoir, which was written by Dr. Blanford, records the results of a survey which he made of the State during the season 1862-63, with the assistance of Messrs. Wynne and Wilkinson. The general geology of the country is so fully

dealt with in it, that I have not much to add to it, especially as I could devote only about four months to the work, and my attention was directed to economic inquiries in which the State is interested. The geological sketch which follows is based chiefly upon the observations of Dr. Blanford and his colleagues. It is only in the section on economic geology that I shall have to notice a few things which either escaped their observation—and in a general examination they well might do so,—or were noticed in a casual way.

## III.—GEOLOGICAL SKETCH.

The following formations occur in the State (in descending order) :—

4. Alluvium.
3. Tertiary system (Nummulitics and higher beds).
2. Deccan and Malwa trap.
1. Cretaceous (Bagh beds).

### 1.—Cretaceous system.

This system consists of—

(A) Sandstones, superposed by (B) Limestones. It is best exposed in the Deva valley between Sulpán and Dumkhal. Here the portion of the inlier west of the Deva (that within the Rájpiplá State) measures about 6 miles north and south and 4 miles east and west at the widest part.

**Area and Lithology.**

Four inliers of the Cretaceous rocks were met with in the Gardeshwar taluka. Of these, two are situated north of the Narbada—one extending from Nasri and Valpur westward to Khadgada and Sultanpur and the other from Limkhetar south-westward to Vanji. The other two occur partly north of the Narbada and partly south of that river—one between Vadgam and the Falls of Mokhadi, and the other extends from Limdi and Navagam to south of Gora. A small patch of the Cretaceous rocks occurs in the Nándod taluka south and south-west of Sakva.

A.—The sandstones are massive, coarse and conglomeratic towards the base and finer grained above. They are generally white, but occasionally tinted red or brown. False-bedding is common. Owing to the numerous intrusions of the Deccan trap which intersect them throughout the area, the sandstones have been considerably altered. Generally, they may be described as quartzitic sandstones, and, in places, as quartzites.

The base of the sandstones was not observed anywhere. Their thickness must be considerable. On the Deva river, which exposes superb sections, scarps of sandstone some 800 feet high occur in places. As they extend for miles and are everywhere found inclined, their actual thickness must be several thousands of feet. But the dips being inconstant both in amount and direction, I could not attempt even an approximately accurate estimate of it without giving more time than I could spare to the examination.

The sandstones are superposed in places—Mathasar (3 miles south-west of Sulpan), east of the Deva river near Sulpan, etc.—by a brownish limestone crowded with a species of *Ostræa*. It appeared to me to resemble *O. Leymerii.* If it be identical with that species—a point which is yet to be settled—then the sandstones may be correlated with those higher up the Narbada valley which have been described by me under the designation of "Nimar sandstone."[1] The increase in thickness of that group westward near Ali and Kawant was noticed by me, and what has been said above shows still further increase in that direction.

B.—In Dr. Blanford's memoir the limestones are described as "calcareous shales"—a description which is hardly accurate. The limestones are usually black, occasionally greyish-white, or greenish.

They are generally fine grained and compact; but coarse siliceous or shaly strata also occur. Like the underlying sand-stones they have been greatly affected by intrusions of the Deccan and Malwa trap which are seen to pierce through them everywhere. In fact they have, as a rule, been altered into marbles. The individual beds vary in thickness from an inch or two to several feet. Specks of iron pyrites are disseminated through them in places. They were specially noticed in the valley of the Todakhal stream (about half way between Sulpan and Dumkhal).

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[1] *Memoirs, Geological Survey of India*, Vol. XXI, pp. 23—35.

The relation of the limestones to the sandstones is not quite clear. There may be a slight unconformity between them.

The thickness of the limestones is not so great as that of the sandstones. Still, in the Todakhal valley it is probably not much less than a thousand feet.

**Disturbance.**

Both the sandstones and the limestones have been disturbed, and not seldom considerably so. Folding (synclinal as well as anticlinal), faulting, crushing and twisting were noticed in places. The dominant strike is north-east to south-west.

**Age.**

The limestones have been correlated with the Bagh beds by Dr. Blanford. Lithologically, however, they are as dissimilar as any two sets of rocks could possibly be.

In appearance the limestones strongly resemble the Vindhyan limestones of Chhattisgarh and other places. The underlying sandstones also might well be taken for Vindhyan sandstones as, indeed, they actually were at one time by Dr. Blanford.[1] The limestones have nowhere yielded the fossils which are so characteristic of the Bagh beds. In fact, except in the band of limestone interposed between them and the underlying sandstones, which has been referred to above, I did not find a trace of a fossil in them anywhere. This is all the more surprising as they are immensely thicker than the Bagh beds and were apparently deposited in a deep and tranquil sea. It is highly probable, however, that both the change in appearance and the obliteration of fossils are attributable to the metamorphism of the Rájpiplá rocks due to igneous contact. The determination of the age of the Rájpiplá beds will probably depend to some extent upon the identification of the fossil *Ostræa* which has been mentioned above. The presumption, however, is in favour of the correlation suggested by Dr. Blanford.

## 2.—Deccan and Malwa trap.

**Area and Lithology.**

The rocks belonging to this series cover by far the greatest portion of the State. Porphyritic traps with greyish-white felspar are very conspicuous in the Dediapada taluka; and amygdaloidal traps

[1] *Memoirs*, Vol. VI., pt. 2., p. 185,

appeared to be commonest in the eastern portions of the Valia and Jhaghadia talukas. Tuffs are met with at various places, notably near Rájpiplá and south of Samaria and Mota Amba (Nandod taluka).

Several interesting occurrences of trachytic rocks were noticed in the trap area in the Valia taluka. The largest of these, which includes a hill called Karia hill, lies between the villages of Avadhra and Baleshwar, and is about two miles and a half in length and a mile and a half in breadth. The second occurrence is south of the village of Ashnávi and forms a hill called .Bardariá, and the third north of Pathar and east of Koyliván.

In all these places the trachytic rocks appeared to have intruded through the Deccan and Malwa trap.

**Dykes.**

Dykes abound throughout the area. They usually take an east-west direction. The dyke rock is generally crystalline.

**Veins of calcite.**

Veins of calcite, or a mixture of calcite and quartz, were encountered at various places. They occur in the amygdaloidal traps and are most abundant in the western portion of the trap upland where those rocks are found in great force. These veins will be noticed in detail in the section on Economic Geology. Like the trap dykes, the most considerable of them were found to take an east-west direction. Veins and geodes of chalcedony and other forms of quartz are rather rare. The most noteworthy veins of that description were met with at Jespore, Vellavi, Tapda and Ghantoli.

Throughout the area the traps were found more or less disturbed. The prevailing dip is southerly.

**Age.**

The extravasation of the trappean rocks took place some time after the elevation and disturbance of the Cretaceous rocks described above. Dykes and intrusive sheets of the former are beautifully seen piercing through or following the bedding planes of the latter along the Narbada river, between Gora and Sulpan and also at several places in the Deva valley. In fact in going over the area doubts often assailed me as to how far the trappean rocks which now surround the Bagh inliers are of intrusive origin, and to what extent they are lava flows

deposited upon a much denuded surface of the Cretaceous rocks. The problem is such an intricate one that I could not attempt to solve it within the time at my disposal. There can be no doubt, however, of the age of the traps being long subsequent to that of the Bagh beds.

The upper limit of the age of the traps is obtained in the western portion of the State. There the Lower Tertiary strata are deposited upon a denuded surface of the trappean rocks; and the materials of the former are to some extent derived from the disintegration of the latter. So the age of the trappean rocks is intermediate between the age of the Bagh Cretaceous beds and that of the Nummulitics.

## 3.—Tertiary system.

**Lithology.**

The rocks belonging to this system cover the western portion of the State comprising parts of the Jhagadia and Valia talukas. They are nowhere well exposed, and only disconnected sections are visible in the streams which flow through the talukas, the Bhundra, the Kaveri, the Amaravati and the Kim. Lithologically the system is composed mainly of alternations of siliceous and argillaceous strata. The former are as a rule soft, and often coarse enough to be styled grits. Occasionally they are conglomeratic. Two well-marked horizons of the conglomerates were noticed in the area—one at the base of the series as exposed in the area under description, near Maljipura, Ambos, etc., and the other towards the top as at Kandh, Limet and the vicinity of Jhagadia. In the basal conglomerates trappean pebbles are common; but in the upper conglomerates they are either very rare or entirely absent; there occur instead in the latter pebbles of agate or other forms of quartz which are very abundant in the Ratanpur-Damlai area, or rolled pieces of limestone and calcareous sandstone derived apparently from older, subjacent strata, as is most conspicuously the case at Limet, Hirapur, Kandhre. The lower gritstones and conglomerates with subordinate bands of clay are fairly well displayed in the Amaravati stream between Ambos and Vagadkhol, where they are superposed by a great thickness of clay beds inter-

**Lower group, Nummulitics.**

calated with thin bands of limestone, in places very fossiliferous, containing nummulites, gastropods, brachiopods, etc. The clays where exposed are more or less ferruginous, presenting various tints of red and lilac.

Occasionally, as near Padvania, they are sufficiently ferruginous to be worked as red ochre. Elsewhere they are converted into laterites. This transformation of the clays into laterites is well seen at several places, as near Borjai and near Valia. The laterite forms a thin crust (not more than 6 feet in thickness) over the clays. There is a large spread of such laterite in the Valia taluka extending from Borjai and Panvadi through Vagadkhol and Valia to Dungri and Karsadh. At the last-named place the laterite is covered up by alluvium and was only visible in a well at a depth of about 13 feet from the surface.

**Upper group.**

The upper conglomerates and grits are well seen about Kandh, Limet, Damlai and Ratanpur. They too are superposed by clays which are sometimes siliceous or calcareous or both. Thin bands of limestone also occur, but they are either unfossiliferous or the fossils they contain are different from those of the lower group mentioned above. Mr. Blanford found *Balanus* in some abundance at Singpur, below Hirapur, just outside the Rájpiplá State. I found fossil leaves in some quantity in clay rocks at Bharan. As in the lower group, the clays towards the surface become more or less ferruginous, being tinted red, yellow and purple, and are in places lateritised. They are well seen in the vicinity of Ratanpur, Bhimpore, Damlai, etc. East of Padvania numerous fragments of fossilised wood (monocotyledonous) were met with in association with a lateritic rock. But the sections are so obscure that it is difficult to tell whether this rock is to be located in the lower or the upper of the two groups which have been described above.

**Disturbance.**

The strata belonging to both the groups are disturbed throughout the area, and sometimes, as in the neighbourhood of Jhagadia, considerably so. But as a rule the dip does not exceed 10°, and the prevailing direction is north-westward. Between Ratanpur and Damlai the strata have undergone anticlinal folding, the dips near the latter place pointing south and those near the former in the opposite direction.

**Age.**

The Nummulitic age of the lower of the two groups described above is established by palæontological evidence. That the strata of which the upper group is composed were formed at least partly by the denudation of those belonging to the lower is shown by the presence of rolled fragments of limestone and calcareous sandstone from the latter in conglomerates which form the base of the former. The palæontological contrast between the two groups is also remarkable. On account of the paucity of good sections and the discontinuity of the few that occur in the area, the two groups could not be separated on the map. But my observations have led me to confirm fully the surmise of Dr. Blanford that the upper group is younger than the lower and is probably of the same age as the Perim beds (pliocene).

### 4.—Alluvium.

The alluvial deposits were nowhere closely studied in the valley of the Madhumati. Close to the trap hills, where their base is seen, the thickness amounts, in places, to nearly eighty feet. Bands of trappean pebbles occur at various horizons, from the top to the bottom. Calcareous concretions are generally abundant and tufaceous limestone is by no means uncommon. In places the sandy beds are sufficiently hardened to be called sandstone.

## IV.—ECONOMIC GEOLOGY.

### 1.—Carnelian and Agate.

The carnelian mines of Ratanpur in Jhagadia taluka have long been celebrated. The first authentic reference to them, however, does not appear to date earlier than the commencement of the sixteenth century. The "Carnelian hills seventy miles from Cambay" referred to by Varthema (A.D. 1503—1508) can be no other than those in the vicinity of Ratanpur. About this time, according to a tradition of the lapidaries of Cambay, an Abyssinian merchant named Bawaghor established a carnelian

factory at Limodra (or Nimodra).[1] At first the stones were prepared by Mahomedans, but the Hindus soon took to the craft. The merchant died at Limodra, and a shrine was raised to his honour on a hill close to the carnelian mines now well known as the Bawaghor hill. "The Sidi (Abyssinian) merchant," says the writer of the Bombay Gazetteer, "is still remembered by the Hindu agate workers. Each year on the day of his death *Shravan Sud Purnima* (July-August full moon) they offer flowers and cocoanuts at his tomb. As it is far to go from Cambay to Bawaghor, they have in Cambay a cenotaph *takiya* in his honour, and those of them who are settled in Bombay have brought with them this memorial of the founder of their craft. The Cambay agate workers assert that the well-known shrine of Bawaghor was raised in honour of their patron. According to their story, while wandering from place to place as a religious beggar, the Bhawa did business in precious stones, and becoming skilled in agates set up a factory at Nimodra (Limodra). Here he prospered and died rich." Limodra appears to have continued to be the principal seat of the carnelian industry during the 16th century. According to Barbosa (1514) the stones were polished and worked there into rings, buttons, beads, etc., and merchants from Cambay used to come to Limodra to buy them. In the beginning of the 17th century the seat of the carnelian industry appears to have been transferred from Limodra to Cambay. Henceforth only the preliminary operations of sorting the stones and exposing them to fire to develop the colour were performed at Limodra. They were then taken to Cambay to be cut, polished and worked up.

[1] *Gazetteer of the Bombay Presidency,* Vol. VI (1880), p. 206. According to the writer of the Gazetteer the factory was established at Nandod. I have but little doubt, however, that the place was Limodra. Nandod is 22 miles (as the crow flies) eastward from the mines. In the beginning of the sixteenth century it was a place of no great importance, and there is no tradition of the existence of a carnelian or, indeed, of any other industry of importance there. Limodra, on the other hand was within 4 miles of the mines. Its ruins testify to its having been a place of great importance as early as the beginning of the 11th century, and inscriptions, on the footstool of an image of Rikhadevji found there are dated Sambat 1126 (A.D. 1004). Barbosa (1514) refers to Limodra as the headquarters of the carnelian industry. Even now the preliminary operations of sorting and exposing the stones to fire to develop their colour are carried on there.

Speaking of Cambay, Tavernier (1651) says that it was there that the agates and carnelians were worked into cups, knife-handles, beads and other sorts of workmanship. "Of eighteenth century travellers, Hamilton (1700—1720) mentions, among articles made at Cambay, stones for signets and rings, some of these worth double their weight in gold, cabinets of stone, in some cases fourteen or fifteen inches long and eight or nine deep, worth from £30 to £40, bowls and spoons of several sizes, handles of swords, daggers and knives, buttons and stones to set in snuff boxes of great value (New Account, I, 140—145). Half a century later, Tieffenthaler says that the white Ratanpur agate, baked red at the mines, was in Broach and Cambay worked into vases, little plates, basins, and other pieces, and sold in Surat and thence taken to Europe."[1]

In 1805 the value of manufactured carnelians and agates exported from Cambay was estimated at £9,490. The returns for the five years ending 1878 give an annual average of £7,000.

**Mode of occurrence.**

The carnelians and agates which in the vernacular are comprised under the general name of *akik* occur in the conglomerates of the upper group of the Tertiary system found in great force about Ratanpur, Damlai and Dholikuva. The following strata were met with in a recently abandoned pit near Damlai which was cleared for my inspection:—

| | Feet. |
|---|---|
| (1) Soil with scattered *akik* pebbles . . . . . | 6 |
| (2) Conglomerate, somewhat ferruginous with *akik* pebbles | 15 |
| (3) Rather loose *akik* pebbles . . . . . . . | 3 |
| (4) Reddish ferruginous sand . . . . . . . | .. |

Rather good pieces of *akik* are sometimes found in (2) but the most paying stratum is (3). I was informed that in the pits on the deep side the conglomerate (2) is interstratified with clays.

It should be noted that the strata (2) and (3) are composed exclusively of fairly well-rounded pebbles of different forms of chalcedony (especially carnelian). That they have been derived from the disintegration of the trap beds hardly admits of any doubt. But these beds must have been very different from those

[1] *Gazetteer of the Bombay Presidency*, Vol. VI, 207.

which are seen at the present day in the adjacent trap area (east of that occupied by the Tertiary rocks), where veins and geodes of chalcedony or any other form of quartz are, as have been noted above, very scarce. Incidentally it may be mentioned that the *akik* pebbles throw some light on the age of the Deccan and Malwa trap. As has been noticed before, they are rare in the lower or the Nummulitic group, but are very abundant in the upper group which is probably of pliocene age. It would appear that by the beginning of the Tertiary period there had not lapsed sufficient time for the formation of those veins and geodes of carnelian and agate the disintegration of which yielded the *akik* gravels of the Ratanpur-Damlai area.

**Size of pebbles, varieties, etc.**

The *akik* pebbles are usually two or three inches along the longest diameter. As raised from the mines they are light-coloured with generally a slight milky tinge. They are chipped at the mines to see if they have any flaws. Those that are approved are carried in baskets to Limodra. Three annas per basket is paid for stones from one inch to about three inches along the largest diameter; and eight annas per basket for stones of larger size.

At Limodra the stones are exposed to the sun for about four months. They are then partially baked in the manner described by Dr. Copland.[1] The following description of the effect of the baking process is given by the writer of the Bombay Gazetteer :—

"Of yellows, maize gains a rosy tint, orange is intensified into red, and an intermediate shade of yellow becomes pinkish purple. Pebbles in which cloudy browns and yellows were at first mixed are marked by clear bands of white and red. The hue of the red carnelian varies from the faintest flesh to the deepest blood red. The best are a deep, clear and even red, free from cracks, flaws or veins. The larger and thicker the stone the more it is esteemed. White carnelians are scarce. When large, thick, even-coloured and free from flaws, they are valuable; yellow and variegated stones are worth little."

[1] See Appendix.

The writer of the Gazetteer mentions three stones which are left unbaked:—"An onyx called *mora* or *bawaghor*, the cat's-eye called *cheshamadar* or *dole*, and a yellow half-clear pebble called *rori*."

When I visited Limodra last January (1907) I did not hear of any such stones, nor of any baked stones other than those which are tinted red or yellowish. Probably my informant, representative of the late lessee of the Ratanpur mines at Limodra (a Cambay merchant), who was there only to despatch the remainder of the outturn of the previous season, did not know much on the subject himself, or, if he did, was unwilling to impart to me the information he possessed.

The baked stones which I saw at Limodra are tinted red or yellow. I did not see any white ones. I was informed that the baked stones were divided into the following four classes according to their colour and size:—

| | | |
|---|---|---|
| 1. Selan | very deep-red | (selling at Rs. 100 per cwt.) |
| 2. Madhyam | light-red | ,, ,, ,, 50 ,, ,, |
| 3. Tukri | ,, | ,, ,, ,, 20 ,, ,, |
| 4. Malai | ,, | ,, ,, ,, 10 ,, ,, |

Mr. R. B. Foote, late of the Geological Survey of India, who paid a visit to Limodra about 15 years ago, was furnished with the following classification of the stones by the then lessee (a Parsi merchant)[1]:—

| | |
|---|---|
| 1. Jerda<br>2. Maddya | very light colour. |
| 3. Mactaria | white and bluish. |
| 4. Lambidunghi | good colour, red. |
| 5. Rodi Damli | ,, ,, (small). |
| 6. Moti Damli | common kind. |
| 7. Asli<br>8. Baman | white to yellowish after baking. |
| 9. Devnapug. | |
| 10. Datora | white. |
| 11. Bimpore | large agates (rare). |
| 12. Pipodra | poor stones. |

It will be seen that with the possible exception of "maddya" which is very likely identical with "madhyam," there is not a single name which is common to the two classifications. The list

[1] *Geology of the Baroda State*, p. 140.

given by Mr. Foote's informant is more comprehensive than the one given by mine, as the latter is confined only to red carnelians. But even then the discrepancy is very marked. Several of the names in Mr. Foote's list are apparently given after villages at or near which the stones occur. Damli is probably the same as Damlai, near which village there occurs, as has been noted already, an important group of carnelian mines; and in "Bimpore" is recognised the village of that name near Rajpardi Railway station where I picked up a large piece of beautifully variegated chalcedony measuring about 4 × 3 inches.

The stones, after being partially baked and slightly chipped to ascertain how they are coloured and whether they have any flaws or cracks, are sorted, and then transported from Limodra to Cambay to be there worked up into beads, necklaces, wristlets, armlets, etc. A very interesting description of the processes of sawing, chiselling, polishing, etc., is given by the writer of the Bombay Gazetteer.[1] Though it was written as long ago as 1878 it still holds good, at least to a great extent.

There would appear to be considerable room for improvement in some of the processes of manufacture adopted by the Cambay lapidaries.

**Mining.**

No mining operations were carried on during the winter, 1905-06. So I could only visit the deserted pits. There are two groups of these, about two miles apart, one near Damlai, and the other close to Ratanpur. No work has been carried on in the Ratanpur area for some years past, as the quality of the stones there is considered to be inferior to that of the stones in the Damlai area. The deserted pits in the latter area, which are marked by mounds of rejected gravel, cover an area about three-quarters of a mile in length and less than a quarter of a mile in width. The strike of the *akik* beds is very nearly E. S.E.—W.N.W. and the dip is S.S.W. I was informed by the men who had worked the pits during previous seasons that the stones improved in size and quality on the dip side, but the workers could not proceed far in that direction on account of trouble with water.

1 *Op. cit.* Vol. VI, pp. 201—205.

Near the outcrop the pits are from 25 to 30 feet deep. One pit which was cleared for my inspection was found to be 26 feet in depth.

The deepest pits in the direction of the dip were reported to me to have gone down to about 70 feet.

Mining is still carried on as it was when the carnelian beds were first opened up centuries ago. It is, I need hardly say, very unsystematic and wasteful. One or more pits according to the demand are sunk during the cold weather, and as much gravel is extracted from them as is possible by driving galleries for short distances in various directions. The roof partially falling in during the monsoon, when no work is carried on, the old pits become unworkable in the next working season and fresh ones are dug at a safe distance from them. A large quantity of valuable material is thus left unworked. The amount which has thus been wasted in the past must be enormous.

If mining were conducted on modern methods not only would all this waste be prevented, but it would be possible to carry on operations to much greater depths than at present—depths where carnelian and agate pebbles of larger size and better quality than those extracted at present are found. The higher value which such stones are expected to fetch will pay for the larger initial outlay of modern mining.

The conglomeratic bed[1] just above the most valuable layer of *akik* appeared to me to be firm enough to afford a tolerably good roof. Timbering would, however, be necessary to some extent.

**Output of the Carnelian Mines.**

During the five years 1902—1906, the *akik* mines were leased out to a contractor on a fixed royalty of three thousand rupees a year. The total quantity of stone raised within that period was about 100,000 cubic feet. The annual output was thus about 20,000 cubic feet.

## 2.—Iron ore, Bauxite, Ochres.

**Laterite as iron ore; slags.**

The laterite of the Tertiary area[2] (Jhagadia and Valia talukas), which covers about 16 square miles, was very largely utilised

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[1] See *ante*, p. 188.

[2] See *ante*, p. 175.

by the ancients as iron ore. Extensive mounds of slags were encountered at various localities, among which Limodra, Bhimpore, Amaljhar and Padvania may be specially noted as being either on or close to the railway line. Ground slag being now largely used mixed with cement for floors and pavements, the large quantities of it lying at those places should have a ready sale at such places as Surat, Broach, Baroda and Ahmedabad. There are calcareous beds in the Tertiary series which appeared to me suitable for the manufacture of cement. If actual trial confirms this conjecture of mine, the enormous quantities of slag just mentioned which occur in the Tertiary area could be utilised for the manufacture in the Rájpiplá State of an artificial stone like the "Patent Stone" now made and largely used in Bengal. An idea of the quantity of slags available may be formed from the fact that at Limodra they cover an area of about 6 acres, and average 5 feet in thickness.

**Quality of the Ore.**

As might be expected, the laterite as an ore of iron is of very variable quality. An average sample from Dungri was analysed by Dr. C. Schulten with the following result:—

| | |
|---|---|
| Oxide of iron | 73·17 |
| Alumina | 9·26 |
| Silica | 10·68 |
| Lime | 1·20 |
| Water | 4·90 |
| Loss | 0·79 |
| | 100·00 |

**Prospects of an Iron industry at Rájpiplá.**

This analysis proves the ore to be of good quality, and from the extensive area covered by the laterite a very large quantity of it may be expected. But until workable caking coal is found in or near Guzerat, the question of the regeneration of the now extinct iron industry of Rájpiplá cannot be seriously discussed. I may note in this connection that there is a bare chance of such coal being found in Kathiawar, if not in Guzerat. Within the Rájpiplá State I found, in the Tertiary beds at Bharan, clay beds crowded with fossil

leaves, and I have recommended the sinking of shallow pits in the area. I met with much more promising indications of workable coal in the Gondwana formation in Kathiawar where prospecting operations are now in progress.

**Laterite as a source of Bauxite.**

Besides iron-ore the laterite may yield workable ore of aluminium (bauxite). The percentage of alumina found in a sample from Vasna is rather low (37·51 per cent.), but further investigation may reveal the presence of bauxite with a higher percentage.

**Ochres.**

Red and yellow ochres are found at various places in the Jhagadia and Valia talukas—vicinity of Ratanpur, Bhimpore, Padvania, Vasna, etc. Of all these deposits, the best are the red ochres occurring at Padvania. They have been worked for many years past. Mining is carried on in the same unsystematic way as that in vogue for the carnelian deposits. The following section was exposed in a pit which was opened last cold weather for the extraction of the ochre :—

| | Feet. |
|---|---|
| Soil | 4 |
| Red and white-mottled clay | 15 |
| Red ochre | 4 |

About 3,200 maunds are annually taken out of the State on pack-bullocks by Mahomedan traders (Banjaras). The royalty paid by them is two annas per maund. A sample of the ochre was analysed with the following result :—

| | |
|---|---|
| Oxide of iron | 23·80 |
| Alumina | 21·30 |
| Lime | 2·80 |
| Mangnesia | 1·70 |
| Silica | 35·32 |
| Carbonic acid and water | 14·40 |
| Loss | 0·68 |
| | 100·00 |

## 3.—Limestone, Calcite, Gypsum, Pottery Clay.

**Limestone.**

The limestones of the Tertiary system are of inconsiderable thickness. They did not anywhere appear to be pure enough to yield lime of good quality. Some of them, however, as near Hirapura and Kandh, might be suitable for the manufacture of cement.

Deposits of calcareous tufa are met with at numerous places. Among the more noteworthy of these are Tejpur by the Madhuvati river, about 3 miles south-west of Umalla station (Rájpiplá State Railway); Mota Amba (9 miles east of Nandod); Mota Machi and Rakhaskundi (Dediapara taluka).

A sample of the limestone from Tejpur assayed by Dr. Schulten gave the following result:—

| | |
|---|---|
| Lime | 50·67 |
| Carbonic acid and water | 37·34 |
| Oxide of iron and alumina | 1·45 |
| Magnesia | 0·45 |
| Silica | 10·00 |
| Loss | 0·09 |
| | 100·00 |

**Calcite.**

Veins of calcite were found at sundry localities in the Deccan trap area, the most noteworthy among them occurring at:—

(1) Rupania (Jhagadia taluka).

(2) South of Vali, Khalak and Bamanfalia (Bhalod taluka).

(3) Chandravan, Vadkhunta and Janoti near the deserted village of Sajanwalla (Valia taluka).

(4) Behej (Nandod taluka).

The veins occur in association with amygdaloidal trap and were invariably found to be superficial. The one at Chandravan was found, by digging, to go down to five feet. Below that depth occurs decomposed amygdaloidal trap with nests and strings of calcite.

The direction of the vein at Chandravan was found to be N.N.E—S.S.W. It is 600 feet long and about 30 feet wide. The vein at Janoti near the deserted village called Sajanwalla measured 125 feet in length and 15 feet in breadth.

Though superficial, there is a fairly large amount of calcite available in the area. I did not, however, come upon any specimens transparent enough to be of use for optical purposes. It would, however, yield lime of superior quality.

**Gypsum.**

Gypsum was met with in the clay beds of the Tertiary system at Bhilod by the Amravati river and at Dodvada. It is somewhat earthy, and there did not appear to be any very large extent of it.

**Pottery Clay.**

Clays well suited for high class pottery occur in the Tertiary beds at numerous places in the Jhagadia and Valia talukas. Those occurring west of Damlai appeared to me to be the best.

## 4.—Building Stones.

**The Bagh beds: Marbles and quartzitic sandstones.**

There is a large variety of excellent building stones in the State. The marbles and quartzitic sandstones occurring in the Bagh beds have been referred to already. The marbles are usually of a black colour, but white, greyish and greenish tints are also occasionally met with. The black marbles take a good polish. They occur in strata from 2 or 3 inches to as many feet in thickness. At places they have been much crushed and shivered as at Mota Amba and thus rendered useless. The somewhat frequent presence of iron pyrites is also a drawback. Workable marbles of good quality were met with at the following places:—

(1) A mile south-east of Gora (Gardeshwar taluka) close to the Narbada river, about 12 miles east of Nandod.

(2) About Zulta Amba and Vanji (eastern portion of Gardeshwar taluka, south of the Narbada river).

(3) Mokhadi on the Narbada

(4) The most extensive deposits of black and other marbles occur in the valley of the Todakhail stream (a tributary of the Deva river) about half way between Sulpan and Dumkhal.

The deposits (1) and (3) are favourably situated in regard to river transport, and those near Gora in regard to cart-carriage

as well, there being a good cart road from Nandod to that place.

Quartzitic sandstones well suited for building purpose, as well as for millstones, grindstones, etc., are found in all the outcrops of the Bagh beds. The most conveniently accessible occurrences, however, are those near Gora and Sakva (8 miles east of Nandod). There is an old quarry at the latter place.

**The Deccan trap series.**

The best stone for all ordinary building purposes is a trachytic-looking rock intrusive in the Deccan trap series. In durability and appearance it compares very favourably with the best stones now used in Guzerat, and occupying, as it does, an advantageous situation, it is likely to have a large sale and yield a handsome revenue to the State. The Karia Hill between Zazpore and Goratia, and Bardaria hill near Undi are composed of it. The Karia stone is a greyish white, massive, moderately hard rock. It takes a fairly good polish and resists weathering remarkably well. The area occupied by it would be about 2 square miles. It was rather extensively quarried in ancient times, the memory of which is still preserved in the name of the hill, "Kara", in the Guzerati dialect, meaning masons, and in a fair which is still held annually at the foot of the hill. There are also two caves at the top of the hill, one of which is consecrated to the god Mahadeo and the other affords shelter to his custodian. Barring this solitary habitation the vicinity of the hill is now a dense jungle, and it is no wonder that, though I found that the Karia rock was used in all the old temples and other masonry structures in the western portion of the State, no one could inform me as to where it had come from.

Karia hill is only 7 miles as the crow flies from the Rajpardi station of the Rájpiplá State Railway, and a branch line could be constructed without serious difficulty. The hill is surrounded by basaltic traps which would afford good road metal and ballast. As there is every likelihood of there being a considerable demand for these as well as for the Karia stone in the area between Surat and Ahmedabad, I would strongly recommend the construction of the branch line.

The traps do not afford building stones of superior quality. But at Rájpiplá (the old capital of the State) there are some bedded tuffs which have been extensively used in local temples and other structures. Similar tuffs occur also south of Samaria and Mota Amba.

**Tertiary rocks.**

The rocks of the Tertiary system being as a rule very soft do not afford good building stones. The conglomerates and gritstones and the thin, comparatively hard, calcareous bands occurring in association with the clays in the upper group, as about Hirapur and Kandh, may, however, be used for rough purposes.

The conglomerates and gritstones are quarried at Kandh and Hirapur for grindstones. But they are of very inferior quality.

## APPENDIX.

## Account of the Carnelian Mines in the neighbourhood of Broach by J. Copland (Extract).

"On account of the tigers with which the country abounds, no human habitations were found nearer the mines than Rutunpoor, which is seven miles off. The miners reside at Neemoodra, where alone the stones are burnt. The mines are in the wildest part of the jungle, and are very numerous; they are shafts working perpendicularly downwards, about four feet wide: the deepest we saw was 50 feet; some extend in a horizontal direction at the bottom, but in consequence of the earliness of the season few had reached a depth sufficient to render this return necessary, and in those that had it was not carried many feet. In using the term 'earliness of the season,' it is proper to mention that the pits are such as to prevent their being worked a second year on account of the heavy rains which cause the banks to fall in, so that new ones are opened at the commencement of every fair season. We arrived at the mines about 7 o'clock A.M., when none of the workmen had come except one, who accompanied us as a guide from Reemoodra. We were informed that the fire-damp (hydrogen gas) was not uncommon in the mines, and that the miners did not descend till the sun had risen sufficiently to dispel the vapours. We went to the bottom of one pit, about 30 feet deep, without any assistance from ropes, or ladders, by means of small niches for the feet and hands on opposite sides of the pit, but understood that the miners always made use of a rope to hold by, of which we could not avail ourselves, as the workmen at the close of their labour carry to their homes the simple instruments of their vocation, together with the stones which the day's labour has acquired. The soil is gravelly, consisting chiefly of quartz sand reddened by iron and a little clay. The nodules

may weigh from a few ounces to two or even three pounds, and lie very close to each other, but for the most part distinct, not in strata but scattered through the mass and in the greatest abundance. I saw none of a red colour at the mines; some were blackish olive like common dark flints, others somewhat lighter, and others lighter still with a slight milky tinge. The first our guide informed us would be black when burnt, the second red, and the third white. In this he may have been correct; but I doubt the fact as to the first, which we found in a proportion inconsistent with the well-known rarity of a black carnelian. I sent specimens of each to Captain Hall of the Royal Navy whose zeal in all scientific researches I doubt not has settled this point. I confess myself of opinion that there can be no precise rules drawn from the appearance of the stones before, for that which they will assume after burning; because it depends partly on the degree of heat they undergo.

"A red carnelian by an intense heat will become white; but as far as my observations go, no stone of the former colour is found so in the mines (excepting jaspers), although a large proportion of them assume it at Neemoodra. Many also, after having been burnt, show both colours sometimes distinct and sometimes mixed, and of a pinky blue; while the colour was uniform, or very nearly so, in all which I remarked at the mines. The lightest coloured stones came out of the fire of a much more delicate and transparent white than before, and often surrounded by a cortex of red, but without any distinct line separating the colours. We were unfortunate in the time of visiting Neemoodra, for all the good stones had been removed and only a few heaps of refuse left. I saw none imbedded in rocks as flints are in the chalk; some nodules on being broken showed a mixture of quartz and agate, and others in a crust of quartz minutely crystallized on the inner surface contained a black oxide of iron of a powdery appearance, many pieces of which we found by themselves in the gravel. Hematites chiefly of the brown and green (without red spots) varieties, mocha stones and jaspers of various colours are very common here; indeed the last was found in almost every part of the province we visited on our route; each stone is chipped in the mine to discover its quality, and those which are approved separated from the refuse, heaps of which lay at the mouth of every pit which had been worked.

"I shall now attempt to give an account of the mode in which the carnelians undergo the action of fire, as derived from the testimony of a respectable native attached to the adawlut at Broach, who was formerly in the carnelian trade, and had himself superintended the process at Neemoodra; his account is corroborated by our personal observation, and by what we learned on the spot.

"The stones are brought to this village every evening, spread on the ground exposed to the sun to prepare them for the further process, and turned every fifteenth day till the time of burning, which is only once a year, one month before the commencement of the monsoon. They are then put into round earthen pots about fourteen inches in diameter, the bottoms of which have been taken out, and the pots inverted (mouth downward);

the pieces taken from the bottoms are put inside and placed over the mouths to prevent the stones falling out; in this state the pots are placed side by side in a trench of indefinite length, but of which the depth and breadth are about two feet, having a layer of five or six inches of dry goats' dung below, and the same above the pots.

"This is set on fire about eight o'clock in the evening. All the fuel is consumed before daybreak, when the pots are removed from the trench to the open air for the stones to cool which requires about three hours: after this they are taken out of the pots piled in heaps and again chipped for the same purpose as when taken from the mines, and are finally thrown into a pit where they remain till called for (more to be out of the way of thieves than as constituting any part of the operation). From Neemoodra the carnelians are carried to Cambay by the merchants who come from thence, where they are cut and formed into the beautiful and much sought after ornaments peculiar to the place.

"I ought to mention that the miners do not forsake a pit on meeting with a spring, but merely change their direction, the water never rising to any great height."

# REPORT ON THE SUITABILITY OF THE SANDS OCCURRING IN THE RAJMAHAL HILLS FOR GLASS MANUFACTURE. BY MURRAY STUART, B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 7 and 8.)

DURING the latter half of the season 1907-8 I was deputed to the Rajmahal hills to investigate the district for sand for glass making purposes, as well as for kaolin and fireclay.[1]

The area investigated is that described by V. Ball in Memoirs of the Geological Survey of India, Vol. XIII, Part 2.

The sand deposits in the district can be divided into two groups—namely (*a*) River sands, and (*b*) Bedded sands.

## (*a*)—River Sands.

The only sand in the first group which is at all suitable for glass manufacture is the Ganges sand, which occurs plentifully along the banks of the Ganges.

I have investigated a sample of this sand (20/975)[2] taken from the right bank of the Ganges at Colgong (25°16′; 87°17′) and have made glass from it (20/976). This glass is of a dark-green colour owing to the iron contained in the sand, and is only suitable for the cheapest and darkest kinds of bottles, such as claret and beer bottles, and cannot be utilised for the manufacture of medicine or soda water bottles.

I also made an experiment to determine the effect of treating with manganese, which shows that hock bottles can also be manufactured from this sand; the combined effects of the iron (already present in the glass) and the added manganese (manganese dioxide) giving the brownish red, non-actinic colour of the hock bottle (20977).

The variation in the composition of the Ganges sand throughout the district is negligible, as a slight difference in the percentage of

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1 The results of my enquiries into the latter subject will be published later.

2 The numbers in brackets refer to the registered numbers of specimens preserved in the Geological Survey Museum, Calcutta.

iron present merely causes a slight variation in the tint of green colour produced, which is not of the least consequence for bottle glass. As regards the purification of this sand, it is practically impossible to make much improvement by the ordinary means at present at the disposal of the manufacturer. Some of the iron is present as magnetite, and this of course may be separated magnetically, but the greater portion is present as ferro-magnesian minerals, chiefly biotite mica with a little garnet and iron-stained quartz-grains. It is impossible to remove iron by burning, and since the sand is deposited from water, it is impossible to effect any change in its composition by washing and sieving.

The other rivers in the district where sand occurs plentifully are the following :—

the Godhanee river which flows through the Chuperbhita Coalfield;

the Bansloi river which flows through the Pachwara Coalfield;

the Brahminee river which flows through the Brahminee Coalfield;

the Kujeea river which flows westwards by Godda (24°49′; 87°17′).

The sands in these rivers all contain much more iron than the Ganges sand. The difficulties of access and transport are also great, as no barges or boats come up these rivers in the rains, and in the dry season they are reduced to mere threads of water. The only transport of the district is by bullock or buffalo cart. These facts quite put the sands out of consideration for glass manufacture, as, in the manufacture of bottles, cheapness of crude materials is one of the most important points. Also glass made from these sands would be of a darker colour, and consequently of not such a good quality as the glass made from the Ganges sand.

## (b)—Bedded Sands.

Passing to the consideration of bedded sands :—White Damuda sandstones occur in this district at Mangal Hat (25°4′; 87°51′) and Pir Pahar (25°6′; 87°50′), on the east side of the hills, and in the Hura and Chuperbhita Coalfields on the north-west.

These sandstones are, or rather were, felspathic sandstones, in which now most of the felspathic material has undergone decomposition into kaolin. This kaolin is at present being extracted from the sandstone at Mangal Hat by a system of crushing and washing, and is being sent to Calcutta for the manufacture of porcelain and china-ware by the Calcutta Pottery Company.

I am informed that all the sand obtained as a bye-product in the extraction of this kaolin is being utilised by the Company in the manufacture of their goods. Consequently the glass manufacturer must start with the crude sandstone and extract the sand from it.

To do this it will be necessary to break down the sandstone into sand, and in this operation care must be taken not to crush it so as to give a fine quartz powder, as the presence of very finely divided silica is a distinct disadvantage, and it would have to be removed by careful washing. As in this case the kaolin has to be removed by washing, forming a valuable bye-product which would compensate for some of the cost of "crushing," it is desirable to obtain this kaolin in as pure a state as possible, and the presence in it of finely divided silica would much diminish its value.

Although washing will remove the greater part of the kaolin, I have found it practically impossible to remove it completely by this means (20/979 and 20/980), and in addition to my laboratory experiments on this point, Messrs. J. Walsh Walsh, Glass Manufacturers at Birmingham, England, were kind enough to wash, burn and sieve a small sample of this sand for me under working conditions, and the resulting sand still contains a small amount of kaolin (20/982 and 20/983).

After "crushing" and washing, the sand is still much too coarse and unsorted to be used as it is, and it must be first sieved. Sieving with a No. 20 sieve (20 wires to 1 inch) yields a sand comparable in size with the Fontainebleau sand (20/989) which is the purest and best sand known for the purposes of glass manufacture.

If the standard of quality of the glass required be somewhat relaxed, a No. 16 sieve would yield a coarser sand which would be quite satisfactory for window glass and glass for the cheaper kind of tumblers and pressed ware, and for all but the highest quality glass (20979, 20/980, and 20/981).

A sample brought from Mangal Hat (20/978) was washed and sieved by me with the following results :—

| | |
|---|---|
| Kaolin obtained . . . . . . . . . . | 6·2 |
| Fine sand obtained from number 20 sieve . . . . . | 40·8 |
| Coarser sand obtained from number 16 sieve . . . | 33·0 |
| Waste very coarse sand . . . . . . . . | 20·0 |
| | 100·0 |

Although the sandstone is very false-bedded and alters in character within a few feet in the same quarry, nevertheless these figures may be taken as fairly representative for the amounts of sand obtained, because the samples containing much coarse material contain little kaolin, and those containing higher quantities of kaolin contain little or no coarse material.

The fine sand so obtained (20/979) was tested by me and a potash-lead glass made from it (20/984). The glass obtained was of a very pale-green colour owing to the presence of a small quantity of iron in the sand; but the conversion of the iron which exists in the ferrous state in the green glass, into the ferric state by the usual methods employed by the manufacturers, such as the addition of potassium nitrate to the "batch" (or mixture of raw materials before melting) in the case of a lead potash glass, would make the colouration due to the iron much less conspicuous since the colour resulting from iron in the ferric state is a pale yellow.

In addition to this, however, the colour resulting from the presence of iron is pale enough to come under manganese control, and an experimental glass made by me with this object in view proved that it is possible to manufacture a perfectly clear high-class glass from this sand, suitable for the best cut and table glass (20/985 and 20/986).

The sand obtained from the coarser sieve would make excellent plate and window glass, and with less carefully selected materials would make a very good quality of medicine and soda water bottles.

Still, the objections to this sand are, (1) that it requires crushing in order to be brought into a condition fit for use, and the crushed product would probably require to be washed to remove the fine dust, a process which leads to the loss of a serious percentage of the material; and (2)—a more serious disadvantage—that it con-

tains kaolin, which it is practically impossible to eliminate completely. Each of the test glasses made by me from this particular sand had a top layer or scum of glass containing a large quantity of unvitrified opaque material, which seems to be practically china, occurring in the form of small isolated grains about $\frac{1}{8}$rd of the size of the head of an ordinary pin (20/984, 20/985, and 20/986). Below this layer the glass was perfectly clear and good, and the absence of bubbles in the glass shows that the glass was well fused and that therefore this scum of glass containing opaque white grains has some other reason for its existence than defective or insufficient fusion.

My experiments were conducted in a Fletcher's Injector Gas Furnace at temperatures ranging between 1600° and 1700°F. The quantity of glass made was some 70 grammes, and the glass was kept fused for one hour, when the absence of bubbles showed that fusion had been complete. In the case of the glasses containing these white granular inclusions, I tried the effect of keeping the glass fused for another hour but it had no effect upon them.

It is impossible to say definitely from small tests such as these what will be the effect of this kaolin under working conditions, and the question must be met and dealt with by the manufacturers themselves.

I have studied these inclusions under the microscope, where they appear as a white opaque substance often including and completely surrounding a small quartz grain which is quite isolated from the surrounding glass, and the assumption that they are china or pottery seems to be maintained (microscope slide No. 6422).

For reasons concerning the stability of the glass and the necessity for it to be as little affected by water, alkalies and acids as is possible, it is out of the question to increase the alkali, or "flux," in the mixture of raw materials; and therefore this method of dealing with the kaolin is impossible.

Consequently I fear that this kaolin will prove a serious obstacle to the satisfactory manufacture of glass from this sand, and especially so in the case of the best "flint" glass which is manufactured in "closed" pots with only a small opening to allow the glass to be gathered on the irons by the workmen, and consequently will not admit of the top layer being drawn or skimmed off.

It is worthy of note, however, that these inclusions of what will be practically china all rise to the top, and form a distinct layer or scum, and that the "metal" underneath is perfectly clear and free from them.

The place where these sandstones may be most conveniently obtained is at Mangal Hat, which is about one mile from Taljheri station on the East Indian Railway, to which there is a good metalled road. After Mangal Hat the most convenient place to obtain this sandstone is at Pir Pahar. The occurance in the Hura and Chuperbhita Coalfields is far from any railway, the Hura field being some 27 miles by road from Pir Painti station on the East Indian Railway and the road bad, and the Chuperbhita Coalfield is still further from the railway. Also this sandstone as found to the west of the hills generally contains some white mica, which makes it of an inferior quality to that at Mangal Hat and Pir Pahar.

The supply of these sandstones is practically unlimited.

## Geological Consideration of the Damuda Sandstone.

From my examination of the Damuda white kaolinitic sandstone in this district I have come to the conclusion that the white, iron-free condition in which it now exists was not the condition in which it was originally deposited, but that it was originally a ferruginous sandstone, and that the iron then present has been subsequently removed.

The sandstone as it exists to-day is a white rock which occasionally becomes coarse and grit-like, and contains kaolin throughout. It is very false-bedded and on the west of the hills contains several beds of white clay.

The kaolin exists in two forms in the sandstone, the one form being the decomposition product of felspar originally present in the rock. This is illustrated by the rock exposed at the eastern end of the Chuperbhita Coalfield, which contains kaolin and felspar both partially decomposed and undecomposed. The second form is that of inclusions of white clay deposited contemporaneously as such: these inclusions or fragments of clay range from quite small fragments up to others which are many cubic inches in volume, and their presence in the rock is due to a change of direction on the part of the depositing river or stream altering

the local conditions of deposition, cutting out in places the white clay beds and redepositing the fragments along with the sand.

Occasionally, where a large expanse of this sandstone is exposed, it is seen that a bed of white sandstone passes laterally into red ferruginous sandstone without any break or discontinuity in the particular bed. This is well seen on the west scarp of the hill situated between Lohundia (25°3′; 87°27′) and Simru (25° 2′; 87°25′); but the evidence in favour of the view that there has been a segregation of iron, which was originally present in the rock, lies in the fact that wherever the top of the sandstone is seen it always consists of a dark-red very ferruginous sandstone containing in most cases distinct bands, much richer in iron than the sandstone itself, and obviously due to segregation (20/993 and 20/996). Where the top of the sandstone is not seen, the surface of the white sandstone is often lamellated with thin bands of what is practically a hydrate of iron.

This is well seen just to the south-west of Bora Ghat (25°1′5″; 87°27′), where also there are many fossil plant stems in the sandstone, all of which are preserved in this hydrate of iron (20/995).

In many places, notably south of Bora Ghat and on the western side of the valley lying to the south of Simlong (24°45′; 87°30′) this very ferruginous top layer shows a peculiar modification, and there is developed what may be termed sandstone laterite. This sandstone laterite is a very ferruginous sandstone which is considerably enriched in iron by segregation bands as mentioned above, and which has developed the lateritic structure of cavities and holes, and shows in some instances the characteristic pipe structure of laterite (20/992, 20/997, and 20/999).

This sandstone laterite can be seen in all conditions ranging from very ferruginous sandstone, with iron segregation bands and very few cavities, to a rock indistinguishable from ordinary laterite, and this structure is due to accumulation of iron and not to disappearance of silica.

The proof that this iron once extended right through the rock is seen in the low-lying range of white sandstone hills running north and south to the south-west of Bora Ghat, where, on the western face, very frequent spherical ferruginous segregations are scattered through the white sandstone. These segregations range in size from that of a golf ball to many inches in diameter (20/991).

## LIST OF PLATES.

# THREE NEW MANGANESE-BEARING MINERALS:—VREDENBURGITE, SITAPARITE, AND JUDDITE. BY L. L. FERMOR, A.R.S.M., B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.*

DURING the course of a survey of the Indian manganese-ore deposits several new varieties and species of minerals, mostly containing manganese, have been found. Concerning three of these—hollandite[1] (a manganate), blanfordite[2] (a manganese pyroxene), and winchite[3] (a manganese amphibole)—notices have already been published. Further information about these three minerals is given in a forthcoming memoir on the manganese-ore deposits of India. In the same memoir accounts are also given of three more new minerals, to which the names vredenburgite, sitaparite and juddite have been assigned. Since, however, there is likely to be some delay before this work is issued, I have thought it well to publish the accounts of these minerals in this place also, in order to prevent the confusion and inconvenience that would arise should anyone find the same minerals elsewhere and give them different names to those I have chosen.

Of these new minerals, vredenburgite and sitaparite are manganese-ores containing a considerable quantity of iron. They are probably to be classed with the group of intermediate oxides given on page 220 of the last edition of Dana's Mineralogy. They are distinguished from all other manganese-ores by the fact that as seen in the sun they showed a distinct bronze tint, and from one another by the fact that vredenburgite is strongly magnetic and sitaparite only weakly so.

The third mineral, juddite, is another manganese amphibole. It is distinct from winchite, and, although it has not yet been analysed, its extraordinary and beautiful pleochroism—comparable only to that of the manganese pyroxene, blanfordite, with which it is intimately associated—is considered sufficient to prove that it is a new variety of the amphibole group requiring a new name.

[1] *Transactions Min. Geol. Inst. Ind.*, I., p 76 (1906); *Rec., G. S. I.*, XXXVI, p. 295 (1908).

[2] *Trans. Min. Geol. Inst. Ind.* I, p. 78

[3] *Rec. G. S. I.*, XXXI, p. 235 (1904); *Trans. Min. Geol. Inst. Ind.*, I., p. 79 (1906).

## 1.—Vredenburgite.

**Characters and occurrence.**

This mineral has been found in two different parts of India, namely Beldongri in the Nágpur district, Central Povinces, and Garividi in the Vizagapatam district, Madras. In colour the mineral is a dark steel-grey exhibiting a bronze tint, especially in the sun. In fact it was this bronzy colour that first drew my attention to the mineral at Beldongri ; the difference in tint between this and the ordinary manganese-ore of the mine was most marked, the latter, composed of a mixture of braunite and psilomelame, being of a dark steel-grey to black colour, with sometimes a tinge of bluish. The lustre of the mineral is metallic, but not very bright, except on cleavage surfaces. The Garividi specimen shows a well-marked cleavage, the nature of which is not obvious, but which I would suggest is paralled either to the isometric octahedron or to the tetragonal pyramid according to whether the mineral be isometric or tetragonal ; for it will probably be found to belong to one of these two systems if specimens ever be found showing recognizable faces. The streak of the mineral is a deep brownish black tending to a deep chocolate. Its hardness is about 6·5. The most interesting feature of the mineral, however, is its magnetism, for it seems to be just as strongly magnetic as ordinary magnetite; and, indeed, any one picking up a piece of it and testing it with a magnet would say at once that it was magnetite. That this would be incorrect is shown by the fact that the mineral contains a high percentage of manganese; in fact, about twice as much of this element as of iron. The mineral is, further, distinctly polar, and pieces can be broken off, one end of which will attract one pole of a balanced magnetic needle and repel the other. The coarsely crystallized Garividi specimen is more suitable for this test than the more finely crystalline ore from Beldongri, the latter being of the nature of an aggregate in which the polarity of one individual may neutralize that of another.

The Beldongri specimen was found as a thin band, one inch in thickness, intercalated with the other ores in the south-east corner of the quarry. This ore is moderately coarsely crystalline, as compared with the usual manganese-ores of this part of India, the individual grain averaging $\frac{1}{16}$ to $\frac{1}{4}$ inch

across. This crystalline aggregate is very compact, and in parts the magnetic mineral tends to get mixed with a little psilomelane. A piece, apparently free from this latter impurity and having a specific gravity of 4·74, was selected for analysis, the latter being carried out at the Imperial Institute. The other specimen was obtained from amongst the heaps of ore from the Garividi deposit stacked ready for despatch at the station of the same name. In contrast to the Beldongri specimen this is very coarsely crystalline, a piece about three inches in length consisting of only three individuals interlocking one with the other in a sort of poikilitic way. One of these individuals is two inches long. The Garividi specimen, moreover, does not contain any other admixed mineral. The piece of it chosen for analysis has a specific gravity of 4·84, which is somewhat higher than that of the Beldongri specimen. This may mean that there was a little admixed psilomelane in the Beldongri ore, although the way in which the analysis works out to a definite formula does not support this supposition. The slight difference in specific gravity may be due to slight differences in the impurities that each of the specimens probably contain. The Garividi specimen was analysed by Messrs J. & H. S. Pattinson of Newcastle-on-Tyne.

**Chemical composition.**

The two analyses are given side by side below :—

| | *Specimen No. 1080.* (Beldongri.) | *Specimen No. A.346.* (Garividi.) |
|---|---|---|
| Manganese peroxide ($MnO_2$) | 23·67 | 24·94 |
| Manganese protoxide ($MnO$) | 38·24 | 38·53 |
| Ferric oxide ($Fe_2O_3$) | 28·85 | 31·29 |
| Alumina ($Al_2O_3$) | 1·32 | 2·10 |
| Baryta ($BaO$) | 1·30 | 0·03 |
| Lime ($CaO$) | 1·53 | 0·90 |
| Magnesia ($MgO$) | 0·99 | 1·20 |
| Potash ($K_2O$) | .. | 0·06 |
| Soda ($Na_2O$) | .. | 0·14 |
| Combined silica ($SiO_2$) | 0·91 | 0·20 |
| Free silica ($SiO_2$) | 0·86 | *Nil* |
| Sulphur | .. | 0·03 |
| Phosphoric oxide ($P_2O_5$) | 1·07 | 0·03 |
| Arsenic oxide ($As_2O_5$) | 0·01 | *Nil* |
| Cobaltous oxide ($CoO$) | .. | 0·05 |

| | | |
|---|---|---|
| Nickelous oxide (NiO) | .. | *Nil* |
| Cupric oxide (CuO) | .. | 0·03 |
| Lead oxide (PbO) | .. | *Nil* |
| Zinc oxide (ZnO) | .. | *Nil* |
| Titanic oxide ($TiO_2$) | .. | 0·14 |
| Chlorine and fluorine | .. | *Nil* |
| Combined water | 1·32 | 0·30 |
| Moisture at 100°C | 0·18 | 0·20 |
| Carbon dioxide ($CO_2$) | 0·09 | *Nil* |
| | 100·34 | 100·17 |
| Manganese | 44·62 | 45·62 |
| Iron | 20·19 | 21·90 |
| Silica (total) | 1·77 | 0·20 |
| Phosphorus | 0·47 | 0·02 |
| Specific gravity | 4·74 | 4·84 |

It is evident from the foregoing analyses that these two specimens represent one and the same mineral composed practically entirely of oxides of manganese and iron; all the other constituents being present in insignificant proportions may be regarded as impurities. The question is then to calculate from these two analyses the formula of the mineral.

I will first consider the mineralogical composition of the Beldongri specimen. If the combined silica shown in the analyses be really in this condition then it will probably be as braunite.[1] On this assumption the analysis can be re-stated as follows:—

| | |
|---|---|
| Apatite | 2·47 |
| Calcite | 0·20 |
| Braunite | 9·12 |
| Hausmannite | 53·82 |
| Hematite | 28·85 |
| Impurities— | |
| Alumina | 1·32 |
| Baryta | 1·30 |
| Lime | 0·02 |
| Magnesia | 0·99 |
| Combined water | 1·32 |

[1] Assumed to have the formula $3Mn_2O_3 . MnSiO_3$.

| | |
|---|---|
| Quartz . . . . | 0·86 |
| Arsenic oxide . . . | 0·01 |
| Moisture . . . . | 0·18 |
| | 100·46 |
| Subtract oxygen assumed . | 0·12 |
| | 100·34 |

On the supposition that the combined silica is present as braunite there is no alternative to the above interpretation of the analysis; for the $Mn_3O_4$ and $Fe_2O_3$ are not then present in any simple molecular proportion. But in accordance with this interpretation there should be three constituents easily visible in the hand-specimen, namely, braunite, hausmannite, and hematite. Examination of the specimen, however, does not reveal the presence of more than one constituent. If, on the other hand, we assume that the combined silica is in combination with some of the impurities, then the analysis can be stated as follows:—

| | |
|---|---|
| Apatite . . . . | 2·47 |
| Calcite . . . . | 0·20 |
| $Mn_3O_4$ . . . . | 61·93 |
| $Fe_2O_3$ . . . . | 28·85 |
| Impurities . . . | 5·86 |
| Quartz . . . | 0·86 |
| $As_2O_5$ . . . | 0·01 |
| Moisture . . . | 0·18 |
| | 100·36 |
| Subtract oxygen assumed | 0·02 |
| | 100·34 |

Now the $Mn_3O_4$ and $Fe_2O_3$ are present in the molecular proportions of 3 to 2 as shown below:—

$$\frac{61 \cdot 93}{229} = \cdot 2704 = 3 \times \cdot 09013$$

$$\frac{28 \cdot 85}{160} = \cdot 1803 = 2 \times \cdot 09015$$

Hence we can suppose that they form a mineral of the composition $3Mn_3O_4.2Fe_2O_3$, rather than a mixture of hausmannite and hematite.

Taking now the case of the Garividi analysis, all the constituents may be regarded as impurities accidentally picked up during the formation of the mineral, except the oxides of manganese and iron, to which, as in the case of the Beldongri specimen, we will confine our attention. The oxides of manganese given in the analysis on page 201 correspond to :—

| | |
|---|---|
| Manganese . . . | 45·61 |
| Oxygen . . . | 17·86 |

Now 45·61 manganese requires 17·70 oxygen for the formation of $Mn_3O_4$, so that here also it seems almost certain that the manganese is present in the form of the proto-sesquioxide. Again the question arises as to whether this $Mn_3O_4$ is to be regarded as hausmannite in mechanical admixture with the $Fe_2O_3$ in the form of hematite, or whether the oxides of manganese and iron are in combination as some definite molecule with a definite molecular formula. Calculation shows that the relation between the $Mn_3O_4$ and the $Fe_2O_3$ is not so exact as in the case of the Beldongri specimen. Neglecting all the constituents except the oxides of manganese and iron the composition of the mineral is :—

| | |
|---|---|
| $Mn_3O_4$ . . . . . | 63·31 |
| $Fe_2O_3$ . . . . . | 31·29 |
| Surplus oxygen . . . . | 0·16 |
| | 94·76 |

Now to satisfy of the formula $3Mn_3O_4. 2Fe_2O_3$, 63·31 $Mn_3O_4$ requires 29·49 $Fe_2O_3$, whilst 31·29 is available; that is, there is a surplus of 1·80 $Fe_2O_3$. This is not excessive and may be taken as showing that the Garividi specimen has the same formula as the Beldongri specimen, the extra $Fe_2O_3$ being regarded as a further portion of the impurities.

On the evidence of the foregoing calculations it might then be considered as fairly certain that the formula of this mineral

is really $3Mn_3O_4.2Fe_2O_3$. At first sight, however, there might seem to be an objection to this formula in the fact that the mineral is so strongly magnetic that the iron must be supposed to be present as $Fe_3O_4$ rather than as $Fe_2O_3$. But this is not a real objection, because there are several minerals exhibiting magnetic properties—usually it is true to a much smaller degree than magnetite—that do not contain their iron in the form of $Fe_3O_4$. Thus pyrrhotite or magnetic pyrites, a sulphide of the formula $Fe_{11}S_{12}$, is often strongly magnetic. Ilmenite is often slightly magnetic. Its formula may be written either as $FeTiO_3$, as $(Fe,Ti)_2O_3$, or as $m FeTiO_3\ n Fe_2O_3$. Whichever interpretation be the correct one it is seen that the iron is in the form of either FeO or $Fe_2O_3$. Since hematite ($Fe_2O_3$) is usually non-magnetic it seems as if the magnetism of ilmenite must be due to the presence in it of titanium and not iron. In the same way all the Indian braunites are more or less magnetic. Although the formula of braunite is open to some doubt, as shown in the forthcoming memoir, yet no interpretation of it shows the presence of an $R_3O_4$ group. Now the Indian braunites usually contain an appreciable proportion of iron replacing a part of the manganese. Such iron must, therefore, be in the form either of $Fe_2O_3$ or, less likely, of FeO. It so happens, however, that some braunites are very low in their iron percentage, and yet are still magnetic. Hence we must suppose that, as in the case of the ilmenite the magnetic properties of the mineral are due to the titanium rather than to the iron, so in the case of braunite the magnetism is due to the manganese rather than to the iron. Hence in the case of the mineral under consideration it does not necessarily follow that its magnetic properties are due to the iron, even though it is present in large amount. The manganese may be the cause of the magnetism; but considering the strength of this property it seems more probable that the iron has something to do with the magnetism. It may be that this particular proportion of manganese and iron oxides gives rise to the magnetism. It will be seen from the foregoing that even if the magnetism be entirely due to the presence of the iron it does not follow that it is present in the form of $Fe_3O_4$. It will be interesting, however, to see if the analysis can be interpreted on the supposition that the iron is present in the $Fe_3O_4$ condition.

If in each of the analyses the iron be supposed to be present in the form of $Fe_3O_4$ and the manganese in the form of $Mn_2O_3$ then the amounts of these oxides work out as follows :—

| | Beldongri. | Garividi. |
|---|---|---|
| $Mn_2O_3$ . | 64·08 | 65·51 |
| $Fe_3O_4$ | 27·89 | 30·25 |
| | 91·97 | 95·76 |
| Subtract O assumed | 1·21 | 1·00 |
| | 90·76 | 94·76 |

With this arrangement the formula works out as corresponding in both cases very closely to $10Mn_2O_3.3Fe_3O_4$. Since however, the error in the oxygen is on this interpretation so large, it would be better to suppose that the manganese is not all in the form of $Mn_2O_3$, but that a portion of it is in the $R_3O_4$ group isomorphously replacing a portion of the iron. On this supposition, and using the oxygen, manganese, and iron, as actually determined as the basis of calculation, the composition works out as follows :—

| | Beldongri. | Garividi |
|---|---|---|
| $Mn_2O_3$ . | 28·23 | 35·89 |
| $Mn_3O_4$ . | 34·64 | 28·62 |
| $Fe_3O_4$ . | 27·89 | 30·25 |
| | 90·76 | 94·76 |

The molecular proportions of the three oxides then work out as follows :—

Beldongri

$$\begin{array}{lll} Mn_2O_3 \;.\;\;. = \cdot 1787 & & = 2 \times \cdot 0893 \\ \left.\begin{array}{l} Mn_3O_4 \;.\;\;. = \cdot 1513 \\ Fe_3O_4 \;.\;\;. = \cdot 1202 \end{array}\right\} & \cdot 2715 & = 3 \times \cdot 0905 \end{array}$$

Garividi.

$$\begin{array}{lll} Mn_2O_3 \;.\;\;. = \cdot 2271 & & = 7 \times \cdot 0324 \\ \left.\begin{array}{l} Mn_3O_4 \;.\;\;. = \cdot 1249 \\ Fe_3O_4 \;.\;\;. = \cdot 1304 \end{array}\right\} & \cdot 2553 & = 8 \times \cdot 0319 \end{array}$$

These correspond respectively to the formulæ :—

Beldongri . . $2Mn_2O_3.\ 3(Mn,Fe)_3O_4$

Garividi . . $7Mn_2O_3.\ 8(Mn,Fe)_3O_4$

We have thus arrived at the following alternative formulæ :—

| Beldongri. | Garividi |
|---|---|
| $3Mn_3O_4.2Fe_2O_3$ | $3Mn_3O_4.2Fe_2O_3$ |
| $10Mn_2O_3.3Fe_3O_4$ | $10Mn_2O_3.3Fe_3O_4$ |
| $2Mn_2O_3.3(Mn,Fe)_3O_4$ | $7Mn_2O_3.8(Mn,Fe)_3O_4$ |

Of these formulæ the simplest is the first, to which the analyses correspond more nearly than to any other, if a little of the iron be regarded as impurity in the Garividi specimen. The second is the least probable interpretation as it is then necessary to assume errors of 1·00 and 1·21, respectively, in the determination of the oxygen. Whichever be the correct formula there is no doubt that this mineral is a new mineral species. I propose to call it *vredenburgite* after my colleague Mr. E. W. Vredenburg, under whom I spent my first field season in India and first came in contact with deposits of manganese-ore. Its main interest lies in its combination of strongly magnetic characters with a high percentage of manganese. In consequence of the former property it is liable to be mistaken for magnetite if—as is only natural, considering that up to the present the only black strongly magnetic mineral [1] that has been recognized is magnetite—its chemical character be not determined; whilst, on account of its well-marked cleavage and the fact that it is found in manganese deposits, it is liable to be mistaken for braunite, unless its magnetic characters be examined. The fact that it dissolves up practically completely in acid, without leaving a residue of silica, serves to distinguish it from braunite; so also does its duller lustre on cleavage surfaces and its curious bronzy lustre in the sun. Otherwise, in hardness, cleavage, and specific gravity, there is a remarkable similarity between these two minerals.

## 2.—Sitaparite.

At Sitapár in the Chhindwára district, Central Provinces, there occurs amongst the interesting association of minerals forming the ores of this place a dark bronze-coloured mineral that looks very like the one I have called vredenburgite. It is, however, distinguished from the latter by the fact that it is only slightly magnetic, vredenburgite being about as magnetic as magnetite.

[1] Excluding native elements.

**Characters.**

The actual colour of the mineral may be described as dark bronze-grey, the bronze tint being especially well seen in the sun. It is, moreover, sufficiently well marked for the mineral to be at once distinguished from its associates in the ores in which it occurs. The streak is black, the lustre metallic. The mineral is brittle and tends to break along almost perfect cleavage planes, which may be octahedral. The hardness of the mineral is about the same as that of quartz. The specific gravity seems to be somewhat variable, three pieces showing values for this constant of 4·93, 4·99, and 5·09, the mean value being 5·00. An analysis of this mineral was made by Mr. T. R. Blyth, of the Geological Survey of India, on a piece having a specific gravity of 4·93. The result is as follows:—

**Chemical composition.**

*Specimen No. 843 A.*

| | |
|---|---|
| Manganese peroxide . . | 36·79 |
| Manganese protoxide . . | 26·89 |
| Ferric oxide . . . | 27·60 |
| Alumina . . . . | 1·02 |
| Baryta . . . . | 0·10 |
| Lime . . . . | 6·14 |
| Magnesia . . . . | 1·02 |
| Silica . . . . | 1·17 |
| Moisture at 100° C . . | 0·09 |
| | 100·82 |
| Manganese . . . | 44·09 |
| Iron . . . . . | 19·32 |
| Specific gravity . . . | 4·93 |

Below are compared the figures for the oxides of manganese and iron, and metallic manganese and iron, with those for the two specimens of vredenburgite of which the full analyses are given on page 201:—

| | Beldongri. | Garividi. | Sitapár. |
|---|---|---|---|
| $MnO_2$ . . . | 23·67 | 24·94 | 36·79 |
| $MnO$ . . | 38·24 | 38·53 | 26·89 |
| $Fe_2O_3$ . . . | 28·85 | 31·29 | 27·60 |
| | 90·76 | 94·76 | 91·28 |
| Manganese . . | 44·62 | 45·62 | 44·09 |
| Iron . . . | 20·19 | 21·90 | 19·32 |

It will be seen that there is a striking resemblance between the Sitapár mineral and the two specimens of vredenburgite, particularly in the amounts of ferric oxide, manganese and iron. The difference between the two minerals lies, however, in the state of oxidation of the manganese. Whilst vredenburgite contains considerably more MnO than $MnO_2$, the relative amounts of these two oxides are reversed in the Sitapár mineral. Consequently the Sitapár mineral cannot be made to conform to the formula of vredenburgite. In the case of vredenburgite I regarded the constituents other than the above as impurities, because none of them was present in any important quantity, nor had any important effect on the formula. Their total amount was, however, not so small, being about 9 per cent. in the Beldongri specimen and 5 per cent. in the Garividi specimen.

In the present case one of the constituents other than oxides of manganese and iron is present in sufficient quantity for it to be necessary to take it into account in calculating the formula. This is the lime; and in investigating the significance of this constituent in the formula, I have grouped with it the oxides of barium and magnesium. Below I give the figures for the molecular ratio of each constituent :—

$$MnO_2 = \frac{36\cdot79}{87} = 0\cdot4230 \qquad = 10 \times \cdot0423$$

$$MnO = \frac{26\cdot89}{71} = 0\cdot3787 \qquad = 9 \times \cdot0421$$

$$Fe_2O_3 = \frac{27\cdot60}{160} = 0\cdot1725 \qquad = 4 \times \cdot0431$$

$$\left.\begin{array}{l} CaO = \frac{6\cdot14}{56} = 0\cdot1096 \\ MgO = \frac{1\cdot02}{40\cdot36} = 0\cdot0253 \\ BaO = \frac{0\cdot10}{153\cdot4} = 0\cdot0006 \end{array}\right\} = 0\cdot1355 = 3 \times \cdot0452$$

$$SiO_2 = \frac{1\cdot17}{60\cdot4} = 0\cdot0194 \qquad = \frac{2}{5} \times \cdot0485$$

In the last line I have also given the molecular ratio for the silica, to show that it is present in too small a quantity to be taken into account in working out the formula of the mineral. It will be seen, however, that the CaO, MgO and BaO taken together are

molecularly nearly as important as the ferric oxide. According to the above the formula is as follows:—

$$10MnO_2.9MnO.4Fe_2O_3.3(Ca,Mg,Ba)O.$$

Leaving out the MgO and BaO and grouping together the oxides of manganese this can be stated more simply as follows:—

$$9Mn_2O_3.4Fe_2O_3.MnO_2.3CaO.$$

From this it might be thought that the mineral is only to be regarded as a variety of the very rare sort of braunite having the simple formula $Mn_2O_3$, in which a portion of the manganese is replaced by iron, the one molecule of $MnO_2$ and the three of CaO being impurities. The quantity of the latter seems to me to be too large to be treated as an impurity, especially as the specimen analysed was a portion of one crystal only and was apparently quite pure and free from adventitious matter. Apart from the presence of the lime and excess $MnO_2$, the bronze tint of the mineral is sufficient to show that the mineral is not a variety of any sort of braunite; for the latter usually possesses a rich black colour, and is, moreover, present in the same ore, as a mineral of very different appearance. Another alternative is to regard the iron as being present in the form of $Fe_3O_4$. Under this supposition the formula of the mineral works out as $6Mn_3O_4.4Fe_3O_4.12MnO_2.5CaO$. It does not, even in this form, show any close relationship in formula to any other mineral. Hence it seems better to accept the simpler formula $9Mn_2O_3 4Fe_2O_3.MnO_2.3CaO$, as the best expression of the composition of this mineral, and to regard it as a new species. As the locality where it is found contains such a number of interesting minerals I think this mineral can be most appropriately called *sitaparite*.[1] I do not at present know what is the meaning of the variable specific gravity noted above. It may correspond to a variation in the composition of the mineral in which one constituent is replaced by another without altering the general formula of the mineral. Further work on the mineral, when a larger number of specimens have been analysed, may result in a modification of the formula of the mineral as given above, but it will not alter

[1] To be pronounced with the accent on the third syllable, in which the 'a' is like the 'a' in 'park'. The 'i' in 'Sita' is pronounced like 'ee.'

the fact that the mineral has an individuality that enables it to be distinguished from all other manganese minerals. The only two minerals to which it bears any resemblance are manganmagnetite and vredenburgite. It is distinguished from the former by its bronze tint and weak magnetism; and from the latter which it resembles in its bronze tint, by its weak magnetism.

The other minerals found at Sitapár are hollandite, braunite, a manganchlorite (?), and an arsenate (with phosphate) not yet worked out. The chief ore obtained from this deposit consists, as seen in the sun, of beautiful sparkling silver-grey prismatic hollandite with spots, patches and bands of bronze-coloured sitaparite. Some thousands of tons of such ore have been despatched to the market.

## 3.—Juddite.

Associated with the blanfordite of Kácharwáhi in the Nágpur district there is a manganiferous amphibole with a pleochroism analogous to that of the blanfordite with which it is associated; but it is, if possible, still more beautiful. The tints seen in a microscope slide, showing a considerable number of sections of the mineral, consist of various shades of rose, carmine, lilac, purple, blue, green, orange and orange-pink. These tints are often very delicate and their great variety is doubtless due to the combination of the colours corresponding to the different axes in different proportions in different sections. As crystals of the mineral have not yet been isolated, it is difficult to say which particular sections show the unadulterated axis-colours. But I think the following is somewhere near the true pleochroism scheme:—

$\mathfrak{a}$=carmine,
$\mathfrak{b}$=blue with a lilac tinge, to pale green with a lilac tinge,
$\mathfrak{c}$=orange or pinkish orange.

It will be seen that the colours corresponding to the $\mathfrak{a}$ and $\mathfrak{b}$ axes are somewhat similar to those of winchite; but the $\mathfrak{c}$ axis colour is quite different. The extinction angle $\mathfrak{a} \wedge \acute{c}$ seems to have a maximum value of about 30° in sections showing the $\mathfrak{a}$ and $\mathfrak{b}$ axis colours. Some of the sections showing carmine and shades of green are at right angles to an optic axis, and from

the brushes obtained in these sections it seems that the mineral is positive, so that $\mathfrak{c}$ is the acute bisectrix. I did not succeed in finding a section accurately at right angles to this bisectrix, but one, not very good, figure that approached this position seemed to show crossed dispersion, as one would expect if $\bar{b} = \mathfrak{c}$. One section showing orange and green tints and hence at right angles to the $\mathfrak{a}$ axis was apparently also at right angles to the obtuse bisectrix, this also pointing to the positive character of the mineral. In a basal section showing the characteristic cross-cleavages of amphibole, the colour corresponding to the long axis of the cleavage rhombs is pinkish orange to reddish orange ($\mathfrak{c}$), and that to the short axis is rich violet, the latter colour being compounded of the $\mathfrak{a}$ and $\mathfrak{b}$ axis colours. It seems probable that the mineral is monoclinic and that the $\mathfrak{c}$ axis coincides exactly with the $\bar{b}$ crystallographic axis, and that the $\mathfrak{a}$ and $\mathfrak{b}$ axes lie in the plane of symmetry. But certain anomalies in the behaviour of the mineral suggest the possibility that the mineral may be triclinic, approximating closely to monoclinic in the axial angles. This point cannot be settled at present.

Hence we can say provisionally that this mineral is positive, has its optic axial plane at right angles to the plane of symmetry of the mineral, and shows a pleochroism not shown by any other amphibole yet described. The position of the optic axial plane is interesting because with rare exceptions the optic axial plane and plane of symmetry in the members of the amphibole group are coincident. The only two exceptions to this rule mentioned by Iddings in his 'Rock Minerals' (p. 345) are crossite from California and a blue amphibole from Viezzena Thal.

It is not yet possible to give any details as to the macroscopic or chemical characters of the mineral, because it has not yet been distinguished in hand-specimens from the blanfordite with which it is associated. But the optical characters of the mineral leave no doubt that it is a new variety of the amphibole group; I propose to name it *juddite* in honour of Professor J. W. Judd, F.R.S., and as a respectful tribute from a former student. It gives me special pleasure to be able to associate the names of Professor Judd and the late Dr. W. T. Blanford with two such beautiful minerals as the amphibole and pyroxene found in this Kácharwáhi rock.

## REPORT ON LATERITES FROM THE CENTRAL PROVINCES.

BY PROFESSOR WYNDHAM R. DUNSTAN, M.A., LL.D., F.R.S., *Director, Imperial Institute.*

IN a letter dated the 2nd February 1905 the Officiating Reporter on Economic Products to the Government of India forwarded to the Imperial Institute copies of communications from the Director of the Geological Survey of India, on the subject of the exploitation of the laterite deposits in the Central Provinces, and requested that six specimens of laterites supplied by the Geological Survey should be examined.

The investigation of the laterite deposits of India was commenced by the Geological Survey in 1903, and, as some of the specimens collected during 1903-1904 were found to contain high percentages of free alumina, proposals were made to the Government of India (1) that certain promising deposits of laterite which were being quarried for road metal should be protected; (2) that the information obtained up to that date should be published for the information of those likely to undertake more detailed prospecting operations; and (3) that large specimens should be sent to the Imperial Institute for report and for exhibition.

The Government of India having sanctioned these proposals in December 1904, large samples of the most promising exposures of laterites were collected and the first instalment of these was forwarded to the Imperial Institute in February 1905. These samples are dealt with in the present report.

The observations of the Geological Survey had shown that an enormous quantity of highly aluminous laterites would be obtainable by simple quarrying in parts of the Central Provinces, but it appeared that the low value of the bauxite in European and American ports would not cover the cost of mining and transporting this material.

It was thought, however, that if the extraction of alumina could be carried out on the spot the purified oxide would command a price which would meet the transport charges either for export or for the manufacture of aluminium or its compounds in India.

The question of the profitable extraction of pure alumina in India is referred to below.

## Description of samples.

*Specimen No. 1 Wrj.*, Warjhori, 2 miles S.S.W. of Rupjhar, Baihir tahsil, Balaghat district, Central Provinces.

This specimen consisted of a large block of laterite weighing over one hundredweight. Its colour varied from whitish or light yellow to red, the distribution of the more ferruginous material giving it a mottled to pisolitic appearance. Cellular cavities occurred, some of which contained colourless crystals.

*Specimen No. 2 Rjp.*, 1¼ mile E.N.E. of Rupjhar, Baihir tahsil, Balaghat district, Central Provinces.

The specimen consisted of a large block of laterite weighing over one hundredweight. It had a pisolitic or mottled appearance, and varied in colour from light yellow to dull red. Minute crystals of various other minerals were present.

*Specimen No. 3 Rjp.*, 1¼ mile E.N.E. of Rupjhar, Baihir tahsil, Balaghat district, Central Provinces.

The specimen consisted of one block of laterite weighing about half a hundredweight. Most of the material was of very light colour, compact, and had a distinctly pisolitic structure. Small crystals of other minerals were present.

*Specimen No. 4 Wrj.*, Warjhori, 2 miles S.S.W. of Rupjhar, Baihir tahsil, Balaghat district, Central Provinces.

The specimen consisted of one block of laterite weighing about 20 pounds. It was light yellow with dark red ferruginous segregations. The specimen was fairly compact and amorphous, but showed colourless crystals in the cavities of the mineral.

*Specimen No. 5 Smr.*, West side of scarp, north of Samnapur, Baihir tahsil, Balaghat district, Central Provinces.

The specimen consisted of a block of laterite weighing about 40 pounds. It was minutely pisolitic and of a light terra-cotta colour.

*Specimen No. 6 Smr.*, West side of scarp, north of Samnapur, Baihir tahsil, Balaghat district, Central Provinces.

The specimen consisted of a block of laterite weighing about 20 pounds. It was compact and of nearly uniform terra-cotta colour.

These samples have been examined in the Scientific and Technical Department of the Imperial Institute and have furnished the following results. No attempt has been made to estimate traces of rare elements, which are generally present in residual minerals of this description:—

| | No. 1. | No. 2. | No. 3. | No. 4. | No. 5. | No. 6. |
|---|---|---|---|---|---|---|
| Aluminium oxide, $Al_2O_3$ . | 53·52 | 56·63 | 58·83 | 54·95 | 54·12 | 52·14 |
| Ferric oxide, $Fe_2O_3$ . . | 10·58 | 5·34 | 2·70 | 7·00 | 4·06 | 7·55 |
| Manganous oxide, MnO . | .. | trace | .. | trace | trace | trace |
| Magnesium oxide, MgO . | 0·61 | .. | .. | .. | 0·33 | .. |
| Titanium oxide, $TiO_2$. . | 6·22 | 7·02 | 10·24 | 13·76 | 11·82 | 11 66 |
| Silica, $SiO_2$ . . . | 1·83 | 2·65 | 0·58 | 0·37 | 1·54 | 0·60 |
| Potash, $K_2O$ . . . | 0·30 | 0·12 | 0·12 | 0·06 | 0·07 | 0·13 |
| Soda, $Na_2O$ . . . | 0·89 | 0·39 | 0·13 | 0·36 | 0·14 | 0·21 |
| Combined water . . | 24·04 | 27·14 | 26·80 | 22·76 | 26·87 | 27·09 |
| Moisture . . . | 0·91 | 0·86 | 0·40 | 1·14 | 0·65 | 0·71 |

The analyses of these laterites from Balaghat show percentages of alumina varying from 52 to nearly 59, calculated on the samples as received. By calcination the water would be driven off and the percentages of alumina would then be increased to the following figures:—

| | No. 1. | No. 2. | No. 3. | No. 4. | No. 5. | No. 6. |
|---|---|---|---|---|---|---|
| $Al_2O_3$ . . . . . | 71·2 | 78·6 | 80·8 | 72·2 | 74·7 | 72·2 |

Previous analyses of laterites from the Balaghat district are referred to in Sir Thomas Holland's letter and in the "Records of the Geological Survey of India," Vol. XXXII, page 179. The

following figures may be quoted for comparison with the preceding table :—

| | Rupjhar, Balaghat District. | Samnapur, Balaghat District. |
|---|---|---|
| Aluminium oxide, $Al_2O_3$ . . . . . | 51·62 | 54·20 |
| Ferric oxide, $Fe_2O_3$ . . . . . . | 5·52 | 4·02 |
| Calcium oxide, $CaO$ . . . . . . | 5·25 | .. |
| Magnesium oxide, $MgO$ . . . . . . | .. | .. |
| Titanium oxide, $TiO_2$ . . . . . . | 7·51 | 12·21 |
| Silica, $SiO_2$ . . . . . . . . | 0·05 | 1·55 |
| Water, $H_2O$ . . . . . . . . | 30·72 | 27·93 |

Subsequently in a letter of the 25th February 1905, Sir Thomas Holland referred to the large percentage of titanic oxide found in these laterites. The results obtained at the Imperial Institute show percentages of this oxide corresponding generally to those previously recorded, and there is no reason to doubt that titanic acid does exist in these large quantities in the laterites. With reference to the presence of rare elements in the laterites it may be mentioned that the powdered sample from Katni, which was received subsequently to the specimens from the Balaghat district, is being subjected to a complete examination for these constituents. The results of the analysis of this specimen will be forwarded at a later date.

These laterites from Balaghat compare very favourably with the bauxites placed on the English market. A series of specimens of the bauxites of commerce recently received at the Imperial Institute were found to have the following composition :—

| | $Al_2O_3$ | $Fe_2O_3$ | $SiO_2$ | $TiO_2$ | Combined water. | Moisture. |
|---|---|---|---|---|---|---|
| Irish bauxite from Co. Antrim . . . . . | 42 | 2 | 13 | 6 | 21 | 16 |
| Gibbsite (from Arkansas) . | 54 | 3 | 9 | 2 | 28 | 4 |
| White bauxite from the South of France . . | 63 | 3 | 9 | 4 | 16 | 5 |
| Red bauxite from the South of France . . . | 57 | 21 | 3 | 2 | 12 | 5 |

In the Indian laterites the percentage of silica is low in comparison with the above figures. This feature is of great advantage in the extraction of alumina by Bayer's process as will be shown later in this report.

The chemical properties of the laterites may be stated briefly as follows. The powdered material is readily attacked by dilute sulphuric acid leaving a residue containing most of the silica and part of the titanium oxide. As the solution contains the greater part of the iron, this method could not be utilised for the manufacture of aluminium sulphate. The finely ground mineral is also readily attacked by a solution of caustic soda or potash. The insoluble residue in this case contains the whole of the ferric and titanic oxides. After calcination the mineral is still soluble in caustic alkali though not quite so readily.

The commercial method of extracting alumina from bauxite for the ultimate manufacture of aluminium formerly consisted in calcining it with a mixture of caustic soda and sodium carbonate. The cooled mass when extracted with water gave a solution of sodium aluminate from which the alumina was precipitated by passing in a current of carbon dioxide.

C. J. Bayer's modification of the process (Eng. Pat. 10093, July 13th, 1887) consisted in the precipitation of aluminium hydroxide without carbonating the lye. The solution of sodium aluminate formed by extracting the above-mentioned "melt" with water is very unstable, and, if simply agitated or allowed to stand, aluminium hydroxide separates and the separation continues until the proportion of $Al_2O_3$ to $Na_2O$ is 1 : 6. If the proportion of $Al_2O_3$ to $Na_2O$ in the original solution is 1 : 2 a permanent solution is obtained, and precipitation does not take place unless precipitated aluminium hydroxide is introduced or formed by passing in a little carbon dioxide, when the action proceeds until the 1 : 6 stage is reached.

On a commercial scale the precipitation takes place in a series of iron cylinders each provided with a number of helical blades for agitating the liquid. The top of the first cylinder is connected by a pipe with the bottom of the next and so on. In starting the operation aluminium hydroxide is placed in the first cylinder and the sodium aluminate solution is passed through in a constant stream

A further advance was made by C. J. Bayer (Eng. Pat. 5296, March 17th, 1892) by utilising the mother liquor containing 1 molecule of $Al_2O_3$ to 6 molecules of $Na_2O$ from the process above described, for the direct solution of the alumina in bauxite. The mother liquor is concentrated to about 77° to 88° Tw., fresh quantities of finely ground bauxite are introduced, and the liquid is then heated to about 160° to 170° C. in closed vessels, the pressure developed being 3 to 4 atmospheres. The materials are used in such proportions as to produce a solution containing 1 molecule of alumina to about 1·8 of sodium oxide. The solution is then treated as before in the precipitating tanks.

When silica is present in the bauxite the lyes gradually become exhausted and numerous patents have been taken out for processes designed to eliminate silica or prevent its solution. Many of these appear to be of doubtful utility. Bayer's method consisted in carbonating the lye and recrystallising the sodium carbonate formed, which was then rendered caustic again in the usual manner.

Aluminium hydroxide prepared by the method above described is often known as "crystalline" hydrated alumina and is in a condition in which it can easily be filtered and washed. These two operations are generally carried out in centrifugal machines.

For the manufacture of aluminium by the electro-metallurgical process complete dehydration of the hydroxide is necessary, and for this purpose several special furnaces have been devised for calcining the hydrated alumina at a high temperature.

One used by the Société Metallurgique Française (Fr. Pat. 364736, March 29th, 1906) consists of a series of ovens divided into horizontal chambers, which are worked in succession. The principle on which the ovens are constructed is that the hydrated alumina, which is spread out in thin layers, remains stationary while the zone of combustion is progressively moved forward as the contents of each chamber become completely calcined. The furnaces are fired with gas.

In applying any of these processes to the Indian laterites many of the details would have to be worked out experimentally on the spot.

An electro-metallurgical process of obtaining pure alumina for the manufacture of aluminium has been patented by C. M.

Hall, Niagara Falls, United States of America, English Patent 14572, 14th August 1900. In this process the bauxite is mixed with a small proportion of carbon and is then calcined. Sufficient carbon is afterwards added to bring the proportion up to 8 or 10 per cent.; a quantity of aluminium powder is also added in stated proportion to the ferric oxide, silica and titanic acid present in the ore. The mixture is charged into an electric furnace and kept at an intense heat for a considerable time in order that the impurities (iron, silica and titanium) may be reduced and form an alloy with a small proportion of aluminium, which, sinking to the bottom, can be removed.

In a second patent (C. M. Hall, Niagara Falls, U.S.A., Eng. Pat. 2260, January 28th, 1902) aluminium is not employed, but if the bauxite is deficient in ferric oxide, sufficient iron is added to alloy with the silicon and titanium. The mixture is heated below the point of fusion, allowed to cool, and the partially purified alumina broken and reheated till it fuses. The two operations are conducted simultaneously in one furnace consisting of an inner and an outer chamber. The process was reported to have been carried out successfully with a current of 7,200 amperes at 50 volts.

A similar process (French Patent 344549, July 4th, 1904) has been adopted by the Sociéte Anon. Electro-Metallurgique in which purer alumina is obtained as a bye-product in the manufacture of ferro-chromium by utilising bauxite as a flux in place of lime. The slag so obtained is said to consist of nearly pure alumina.

## Commercial Valuation.

Specimens of the laterites, with the results of their analysis, were submitted to commercial experts, who reported that the mineral in general is of satisfactory quality for the manufacture of aluminous compounds such as sulphate of aluminium, alum, etc. It was stated however that such material could not be sold in this country at a price which would be remunerative after paying freight, unless very low rates could be obtained. Sample No. 3 was said to be the most suitable quality for the manufacture of aluminous compounds.

The value of bauxite suitable for the manufacture of aluminous compounds is about 22*s*. to 23*s*. per ton delivered to United

Kingdom ports. The price obtainable for manufactured alumina in this country varies from £12 to £38 per ton, depending on its purity and to some extent on its physical condition.

## Conclusions.

These reports confirm Sir Thomas Holland's opinion expressed in paragraph 5 of his letter No. 395 of the 25th January 1905 that "in any case the low value of bauxite at European and American ports would not cover the cost of mining and transport to Europe from any part of India removed from the coast."

There appears however to be no great obstacle to the adoption of Bayer's process for extracting alumina in India, and, as the above quotation shows, the manufactured product if of good quality would probably fetch a price which would be remunerative to exporters. The waste of alkali should be small with laterites of a quality equal to the present samples, and the only other necessary material would be lime for reconverting the sodium carbonate into caustic soda.

Much more might be said on the general subject, and as to the details of the processes which might be employed. This however is unnecessary at this stage since it is clear from the facts now presented that the utilisation of laterites in India presents a favourable field for industrial enterprise.

# MISCELLANEOUS NOTES.

## Hunza and Nagar Glaciers.

FROM enquiries I made it appears that some of the Hunza and Nagar glaciers are at present advancing.

The people at Minapin told me that the Minapin glacier has already overthrown one of the pillars placed by Mr. Hayden in the nullah during September 1906.

The Hassanabad and Muhammadabad glaciers, I am told by Wazir Humayun of Hunza, are both steadily advancing, and are now threatening to destroy the waterchannels (kuls) which have been made from these nullahs. The Muhammadabad glacier has already destroyed the upper of the two waterchannels, and is now close to the lower one. I placed a pillar of stones to mark the snout of the Passu glacier. This pillar is on the right bank of the glacier, close to the road, where it begins to descend steeply into the Passu nullah bed. Opposite this pillar on the other bank is a large white stone. Wazir Humayun left orders for the Passu people to erect another pillar on this white rock so there should be no difficulty in finding these marks. I regret that I had not time to visit the Minapin and Hassanabad glaciers and examine the marks put up by Mr. Hayden, and note any movements of these glaciers.

I have made the above notes, as, although the information is only what I obtained from questioning the local men and therefore rather vague, still I thought it might be of interest so far as it goes.

[H. F. BRIDGES, *Captain*,
*5th Gurkhas.*]

## Second note on a Recent Estuarine Deposit below Clive Street, Calcutta.

In Vol. XXXI of these "Records," page 175, Mr. E. Vredenburg describes briefly an oyster-bed found under one of the streets of Calcutta. With the help of Mr. H. B. Preston I have now been able to identify most of the animal remains included in the deposit, and therefore to cast a little more light on its nature. With the exception

of a barnacle (*Balanus patellaris*, Spengler) and a polyzoon [*Lepralia* (*Eschariodes*) *occlusa*, Busk, *var. sive nov. sp. prox.*], the recognizable remains consist of molluscan shells: there are also some small calcareous worm-tubes, as to the identity of which none but a palæontologist would venture to guess, and a fragment of mammalian bone certainly belonging to a carnivore and probably to a large dog or wolf. The following is a list of the shells:—

*Telescopium fuscum*, Ch.—A common species in mangrove swamps, extending its range landwards in the Ganges delta to the environs of Calcutta, round which it is common in ditches. Essentially an estuarine form.

*Paludina* (*Vivipara*) *bengalensis*, Lam.—One of the commonest freshwater shells in Lower Bengal. I have taken it in slightly brackish water near Calcutta.

*Ampullaria globosa*, Swains.—The same remarks apply to this species as to *Paludina bengalensis.* I may draw attention to the fact that operculate shells like these two species are very much more common in the deposits now being formed round some of the "tanks" in Calcutta than non-operculate forms such as *Limnœa*, although the latter are just as abundant in the "tanks." This appears to be due to the greater sensitiveness to the approach of drought natural to a mollusc not provided with an operculum. When a pond begins to dry up, such forms as *Limnœa* make their way to the deeper parts, or, as a final resort, crawl over the damp grass at night to other ponds. Operculate forms, however, are apt to close their opercula and stay where they are, often perishing before the water returns to them.

?*Aricia moneta*, Linn.—There is a small, very much worn shell in the deposit which appears to belong to this species. It is the only mollusc in the collection that is essentially marine, being an inhabitant of clean salt water. As, however, its shell was at one time used as money in Lower Bengal, its presence in the deposit may be purely adventitious. Its worn and polished surface would suggest a different origin from that of the other shells.

*Planorbis exustus*, Desh.—A single specimen. This is a very common mollusc in ponds round Calcutta. During the floods in July, 1907, I found that it migrated into certain brackish ponds at Port Canning on the River Matla (Ganges delta) from which it was usually absent, being a thoroughly freshwater species. When the water evaporated, however, in the succeeding cold weather, and the salt became

concentrated, it disappeared from these ponds. Apparently it cannot endure water that contains more than about 1 per cent. of saline residue.

*Anomia achœus*, Gray.—A common species in the estuaries of the Ganges, often found in water that contains a sufficiently small proportion of salt to be called brackish.

*Arca adamsiana*, Dkr.—A single small and imperfect specimen identified by Mr. Preston.

*Ostrea cucullata*, Bow.—Common in brackish water. In the Matla River it is abundant in water containing only 2·5 per cent. of saline residue.

*Ostrea canadensis*, Tk.—Many large oyster-shells of an elongated form and with a peculiarly elongate hinge occur in the deposit. One of them was sent to Mr. Preston, who writes regarding it: "Mr. E. A. Smith is of opinion with me that this is *O. canadensis*, Lk., though how it got to Calcutta except as ballast it is difficult to imagine." Similar shells, however, are still common in a living state in the Sunderbans, and we have others in the Museum collection which evidently belong to the same species, from Mergui, Penang and Cutch.

It will be seen from what has been said that the deposit is an estuarine one from fairly near the upper limits of brackish water, as is proved by the presence of essentially freshwater species known to live in ponds and canals of water containing a small percentage of salt. The only barnacle present (*Balanus patellaris*) has been found by myself living in a pond the water of which contained not more than about 1·7 per cent. of saline residue. As regards the *Lepralia*, which coated some of the oyster-shells in considerable profusion, we know as yet very little about the estuarine polyzoa of India. Mr. A. W. Waters has published a short note on a specimen submitted to him (*Rec. Ind. Mus.*, ii, p. 110). He says regarding it: "Possibly it is a marked variety of *Lepralia occlusa*, or an ancestor." It is however improbable that the latter supposition is correct taking into consideration the organisms found with the polyzoon; the whole facies of the deposit is recent and there is nothing to prove that this *Lepralia* no longer exists in the estuary of the Ganges, as the molluscs to whose shells it was attached still do. Even if it could be proved to be extinct in its old haunts this would mean very little, for *Membranipora bengalensis*, Stoliczka, another estuarine species, has entirely disappeared within the last forty years from localities near Calcutta in which it was once common.

[N. ANNANDALE.]

## Growth of Alunogen crystals on a Meteorite (Plate 9).

My attention was recently called to a growth of white fibrous crystals on a portion of the meteorite which fell at Cold-Bokkeveld, Tulbagh, Cape Colony, on 13th October 1838; and which had been kept (under ordinary atmospheric conditions prevailing in Calcutta) in a card-board box having a glass lid standing in a show case in the Geological section of the Indian Museum. The specimen was obtained in 1865.

One side of the specimen, which was an original surface of the entire specimen, was quite free from the encrusting crystals, but the other sides, which were fresh fracture surfaces, were entirely covered by them.

On analysis I found the crystals to consist of alunogen (hydrous sulphate of alumina), and their formation is due to the peculiar composition of the meteorite and the favourable conditions of the climate of Calcutta.

Dana states: "Alunogen occurs commonly as the result of the decomposition of pyrite in coal districts and alum shales,"[1] and it has been noticed to form on specimens of the latter in the Geological Survey Offices.

The meteorite is of the stony, non-metallic variety, and is peculiar in that it is carbonaceous.[2]

That the original surface of the meteorite did not undergo this change seems to be accounted for, partly by the surface being vitrified, and partly because the sulphur then must have been fully oxidised by the atmosphere during the falling of the meteorite.

## Explanation of plate 9.

FIG. 1. Portion of the Cold-Bokkeveld meteorite with growth of alunogen (natural size).

FIG. 2. Ditto showing portion of the original surface of the meteorite (natural size).

[MURRAY STUART.]

1 A system of Mineralogy, p. 958.
2 Studien über Meteoriten, C. Klein, p. 13.
British Museum, Introduction to the study of Meteorites, p. 36.

RECORDS OF

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# THE SOUTHERN PART OF THE GWEGYO HILLS, INCLUDING THE PAYAGYIGON-NGASHANDAUNG OIL-FIELD. BY G. DE P. COTTER, B.A. (DUB.), F.G.S., *Assistant Superintendent, Geological Survey of India* (With Plates 10 and 11.)

**Introduction.**

DURING December 1907, and January 1908, I examined that part of the Gwegyo hills which lies south of the village of Nyaungnigyin, and also the area which lies south of these hills, known as the Payagyigon-Ngashandaung oil-field. It will be remembered that these hills have already been mapped on a ¼-inch scale by Grimes[1] and that the country to the north of Nyaungnigyin has been described in detail by Pascoe.[2] The present survey was undertaken with a view to continuing the latter's work towards the south and forming an idea of the prospects of oil in this southern part of the hills, and in what is clearly a continuation of their structure to the south, partially concealed under alluvium, *viz.*, the Payagyigon-Ngashandaung oil-field.

The Gwegyo hills, as will be seen from a glance at the map,[3] run near Nyaungnigyin in two parallel ranges as far south as the village of Minganzu, each range showing a scarp on the east and a dip-slope on the west. To the south of the latter village the hills are represented by a single range, which dies out at the village of Zigyobin. South of this point the country is more or less covered by alluvial deposits, which in three places conceal the

1 *Mem., Geol. Surv. Ind.*, Vol. XXVIII, p. 68.
2 *Rec., Geol. Surv. Ind.*, Vol. XXXIV, p. 261.
3 The accompanying map is taken from the Burma Survey sheets 153, 154; scale 1 inch = 1 mile.

structure and the boundaries of the outcrop of the miocene or, as we may term it with Theobald,[1] the Pegu series, *viz.*:—

(1) between Zigyobin and Payagyigon;
(2) between Yonywa and Kanlwin;
(3) east and south of Ngashandaung.

In contrast to the Gwegyo hills, which have been protected from denudation by a hard layer of sandstone capping the shales of which they are mainly composed, the outcrop of the Pegu series south of Payagyigon is chiefly exposed in stream-beds owing to the partial denudation of the overlying alluvium. Although the southern boundaries of the outcrop cannot be seen, there is no doubt that it ceases close to Ngashandaung, since the Red Silt has been extensively removed on either side of the Pin Chaung, 3 miles south of this village, and here only rocks of Irrawadi age are exposed.

The flora of the area is typically that of the waterless tracts a short distance inland from the Irrawadi river, to which the name "desert zone" has been applied by Captain Gage.[2]

A peculiarity of the Pegu beds, both of the Gwegyo hills and of the country south of Payagyigon, is the abundance of shale and the rarity of sandstone. This has an important bearing on the surface features in two respects:—

(1) the shales, being impervious to water, form excellent reservoirs for the storage of the monsoon rains. Accordingly we find many large tanks throughout the area, especially near Payagyigon. The occurrence of several tanks between Payagyigon and Zigyobin where the Gwegyo hill-range ceases, suggests the presence of beds of Pegu shale underlying the alluvium that separates these two outcrops;

(2) the softness of the shale has caused extensive denudation in the area south of Payagyigon. Here the Pegu series has been denuded to a considerably lower level than the surrounding Irrawadi sandstone plateau, and the outcrop forms an area of depression. In contrast to this area the Gwegyo hills have been protected from denudation

1 Theobald: *Mem., Geol. Surv. Ind.*, Vol. X, p. 80.

2 *Rec., Bot. Surv. Ind.*, Vol. III, No. 1. The Vegetation of the District of Minbu in Upper Burma.

by a hard capping layer of sandstone. The Gwegyo hills and the Payagyigon-Ngashandaung oil-field being separated by a broad belt of alluvium, it seems advisable to treat the two areas separately.

## I.—The Gwegyo Hills south of Nyaungnigyin.

The hills are entirely composed of Pegu strata, and show a preponderance of shales. These are of a steel-blue colour in fresh exposures, but where they have been subjected to weathering their hue is a light olive.[1]

Pegu beds are found also extending for about a mile west of the hill range; and in these higher zones, fossils and selenite occur. I have found no fossils in the lower zones of the Pegu series exposed on the eastern scarp of the hills.

**Fossils.**

The locality from which fossils were obtained is about 2 miles S.S.E. of Kyauktan village, in a stream-bed running northwards towards the village. Three fossil-beds were found exposed in this *chaung*, the highest being about 175 feet above the lowest bed. The specimens from these beds are as follow:—

*Ceratotrochus alcocki*, Noetl.
*Flabellum distinctum*, Milne-Edwards.
*Paracyathus cœruleus*, Duncan.
*Tellina hilli*, Noetl.
 ,, *protostriatula*, Noetl.
 ,, *protocandida*, Noetl.
*Dione protophilippinarum*, Noetl.
*Arca* sp.
*Ostræa* sp.
*Turritella angulata*, Sow.
*Trochus* sp.
*Triton pardalis*, Noetl.
*Cancellaria davidsoni*, d'Arch. et Haime.
*Fasciolaria nodulosa*, Sow.
*Surcula feddeni*, Noetl.

[1] See Pascoe: Gwegyo anticline, *Rec., Geol. Surv. Ind.*, Vol. XXXIV, p. 261.

*Pleurotoma* sp. cf. *woodwardi*, Martin.
*Voluta dentata*, Sow.
*Conus malaccanus*, Hwass.
,, *yuleianus*, Noetl.
*Cypræa* sp.
*Callianassa birmanica*, Noetl.

The fauna above given show that these beds belong to the Yenangyaungian stage of Noetling.

**Thickness of Pegu beds.** The thickness of the outcrop near Nyaungnigyin is perhaps over 4,000 feet, that is considerably greater than that of the Pegu beds exposed in the better known anticlines of Upper Burma. It is a possible conjecture that the lower horizons exposed in this field are to be correlated with the unfossiliferous Sitsyahn shales of Theobald,[1] while the upper beds would be contemporaneous with his Prome series or, as it is now usually called, Yenangyaungian.

**Structure and faults.** South of Nyaungnigyin only westerly-dipping rocks can be seen in the outcrop of the Pegu series. While portions of the crest still remain in the Pagan hills (see Grimes : *Mem., Geol. Surv. Ind.*, XXVIII, p. 66) and also in the northern part of the Gwegyo hills (see Pascoe, *op. cit.*), the crest in this part of the field appears to have been entirely faulted away, and sand rock of Irrawadi age is found on the east of the hills, in juxtaposition with westerly-dipping Pegu beds. I have found no evidence to show whether these faults are lag-faults downthrowing to the east, or thrust-faults with an upthrow from the west ; Pascoe however (*op. cit.*) believes them to be lag-faults. One of these boundary-faults runs N.W.—S.E. from Nyaungnigyin towards Minganzu, a second runs northwards from near Gwegyo to meet it. Although there is no positive evidence that the eastern scarps are bounded by faults south of Gwegyo, the whole country up to the base of the hills being covered by alluvium, yet it seems obvious that such faults exist since boundary-faults are found both to the north and near Payagyigon to the south.

1 Theobald: Geology of Pegu, *Mem., Geol. Surv. Ind.*, Vol. X, p. 81.

## II.—The Payagyigon-Ngashandaung Oil-field.

This field has been divided into six blocks by the Burma Oil Company; I shall therefore refer to the block numbers for convenient reference.

Perhaps the chief point of interest is the prevalence of beds of dark blue and often gritty shale without selenite. The uppermost beds show true sandstones alternating with shale, the former being of a buff or light olive colour, and are well seen in the exposures in stream-beds in block 1, but in the south of the field great thicknesses of blue shaly beds are found in which the nearest approach to a sandstone is a gritty rock of the same colour as the adjoining shale, and composed of grains of quartz in a more or less argillaceous matrix.

In block 1 the outcrop of the Pegu series is at its widest, but it is difficult to estimate the thickness, which is probably not less than 2,000 feet, since the outcrop is faulted. The thickness of strata exposed in the Kye-ma-ngai Chaung, block 5, is probably not much over 600 feet. As the crest is sinking to the south, a decrease in thickness is only what might be expected, but it is worth noting that in contrast to the alternating beds of buff sandstone and blue shale or gritty argillaceous beds of blocks 1 to 4, the exposures in this section show only rocks of the latter type, and the true sandstones seen from blocks 1 to 4 are here entirely absent. It is difficult to explain what has become of them, unless we suppose that they have been removed by denudation previous to the deposition of the Irrawadi beds.

**Unconformity.**

The evidences in favour of an unconformity between the Irrawadi beds and the Yenangyaungian in this field are as follow:—

(1) the sections in stream-beds from blocks 3 to 5 show a sharp division between current-bedded Irrawadi sand-rock containing fossil wood and presumably a fluviatile deposit, to Yenangyaungian dark blue argillaceous beds or shale. Fossils (corals, marine gastropoda and pelecypoda) have been found in these beds within 100 feet of the base of the Irrawadi beds. Thus there is a sudden transition from marine to fluviatile strata;

(2) the Irrawadi series is separated from the Yenangyaungian by a bed of red earth three or four feet thick, some-

times conglomeratic. This bed perhaps represents an old land surface;

(3) little evidence can be adduced from the respective dips of the two series. Such dips as have been obtained appear to point to a slightly greater angle of dip in the Yenangyaungian as compared with the Irrawadi beds, but the latter are so current-bedded that reliable dips are almost an impossibility, and this type of evidence cannot be regarded as very reliable. So much at any rate may be taken as certain that, considering the disturbance of the Yenangyaungian in this field, the Irrawadi beds are less disturbed than we should expect, since about a mile from the Yenangyaungian outcrop only very gentle dips are seen.

**Fossils.**

The Pegu beds of this field contain abundant fossils, and specimens have been collected only from the more important localities. In describing the fossil-zones, block 1 and blocks 4 and 5 have been treated as distinct areas, since they are separated by country covered by alluvium through which it would be impossible to trace a fossil-bed.

## Fossils from Block 1.

Bed 1, a thin band of limestone close to the base of the Irrawadi beds, containing broken remains:—

*Tellina* sp.
*Lucina neosquamosa ?* Noetl.
*Natica* sp.
Sharks' teeth.

Bed 2, at a rough estimate about 900 feet below the base of the Irrawadi beds, and containing a rich fauna, from which some specimens have been already described (*Rec., Geol. Surv. Ind.*, XXXVI, p. 131). The following have been identified:—

*Dendrophyllia* sp.
*Flabellum distinctum*, Milne-Ed.
,, sp. indet.
*Paracyathus cæruleus*, Duncan.
*Ceratotrochus alcocki*, Noetl.

*Pecten kokenianus*, Noetl.
*Ostræa* sp.
*Arca* sp.
*Dione dubiosa?* Noetl.
*Calliostoma blanfordi*, Noetl.
*Vermetus javanus*, K. Martin.
*Siliquaria* sp.
*Scalaria* sp.
*Turritella angulata*, Sow.
*Cancellaria davidsoni*, d'Arch. et Haime.
*Fusus seminudus*, Noetl.
*Oniscidia minbuensis?* Noetl.
*Genota irravadica*, Noetl.
*Voluta dentata*, Sow.
*Ficula theobaldi*, Noetl.
*Cypræa* spp.
*Drillia yenanensis*, Noetl.
,, *protointerrupta?* Noetl.
*Conus malaccanus*, Hwass.
,, sp. indet.
*Nautilus* sp.
*Balanus tintinnabulum*, Linné.
*Oxyrhina spallanzanii*, Bon.
*Carcharodon megalodon*, Agassiz.

Bed 3 is exposed in the Sagyin Chaung. Here there is a bed of reddish brown sandstone with shale above. Some of the fossils come from the overlying shales:—

*Flabellum* sp. indet.
*Mæandrina* sp.
*Pecten* sp.
*Nucula alcocki*, Noetl.
*Dione protophilippinarum*, Noetl.
*Trochus* sp.
*Vermetus* sp.
*Turritella lydekkeri*, Noetl.
*Natica callosa*, Sow.
*Semicassis protojaponica*, Noetl.
*Voluta dentata*, Sow.
*Fasciolaria nodulosa*, Sow.
*Triton pardalis*, Noetl.

*Genota irravadica*, Noetl.
*Conus protofurvus*, Noetl.
" *malaccanus*, Hwass.
" *yuleianus*, Noetl.
*Callianassa birmanica*, Noetl.
Crab remains.

## Blocks 3 and 4.

The following fossil-beds are all exposed in the Taungma Chaung :—

Bed 1, about 100 feet below the base of the Irrawadi series, is a thin argillaceous limestone with fragmentary fossils, including *Paracyathus cæruleus*, *Cancellaria davidsoni*, and traces of pelecypoda.

Bed 2, coral limestone, rather argillaceous, 400 feet below the base of the Irrawadi beds :—

*Ceratotrochus alcocki*, Noetl.
*Paracyathus cæruleus*, Duncan.
*Flabellum distinctum*, Milne-Ed.
" sp. indet.
*Trochocyathus* sp. aff. *nariensis*, Duncan.
*Nucula alcocki*, Noetl.
*Ficula theobaldi*, Noetl.
*Genota irravadica*, Noetl.
*Oliva rufula*, Duclos.

Bed 3, about 420 feet below bed 2, consists entirely of argillaceous beds, in which the fossils are very well preserved :—

*Ceratotrochus alcocki*, Noetl.
*Nucula alcocki*, Noetl.
*Tellina protocandida*, Noetl.
*Turritella leiopleurata*, Noetl.
" *lydekkeri*, Noetl.
*Vermetus* sp.
*Solarium* sp.
*Natica obscura*, Sow.
*Voluta dentata*, Sow.
*Genota irravadica*, Noetl.
*Semicassis protojaponica*, Noetl.
*Triton pardalis*, Noetl.
*Fasciolaria nodulosa*, Sow.

*Oliva rufula*, Duclos.
*Pleurotoma* sp. cf. *woodwardi*, Martin.
" sp. cf. *karenaica*, Noetl.
*Murex tchihatcheffi*, d'Arch. et Haime.
*Conus literatus*, Linné.
Crab remains.

Besides the above fossils, two species of *Nautilus* have been found in this part of the field, one (sp. 1) coming from about the same horizon as the bed described immediately above, and the second and larger species (sp. 2) coming from detritus close to bed 2, blocks 3 and 4. The first species has also been found in bed 2, block 1 (see above).

**Structure, crest and faults.**

The structure of this area is a close parallel to that of the Gwegyo hills. A remnant of the crest is found in blocks 5 and 5A. Its direction is N.-S. similarly to the crest in the north of the Gwegyo hills near Tetma (see Pascoe, *op. cit.*). Between these two points the crest has been completely faulted away by faults upthrowing from the west, or downthrowing to the east, which have brought the Irrawadi series into juxtaposition with westerly-dipping Pegu beds. It is possible that the remnants of the crest in the north near Tetma, and in the south in block 5, are features connected with the sinking of the anticline at these points. At any rate there would presumably be less strain where the anticline was sinking than where there had been a maximum upheaval of strata. There is an excellent section showing the anticlinal structure in the Kye-ma-ngai Chaung, blocks 5, 5A; the fold is sharper than that of Yenangyaung, the dips rapidly approaching 30° close to the crest on either side. The strata are broken in appearance along the crest-line and possibly the crest is faulted. The want of correspondence of the beds on either side of the crest in the above mentioned section bears out this view.

Some steeply dipping strata close to the oil-sand in the Kye-ma-ngai Chaung (see map) may be caused by this fault, which in this locality apparently runs a few yards to the east of the crest.

The dips in blocks 5 and 5A are unreliable, but apparently show that the anticline is sinking to the south.

The crest is cut off by a boundary-fault north of the Burma Oil Company's bungalow in block 4.

The eastern boundary of the outcrop of the Pegu series is faulted in a manner exactly similar to the faulting of the Gwegyo hills. The faulting apparently dies out into folding in the extreme south, as is suggested by the Kye-ma-ngai Chaung section, which shows Irrawadi beds dipping vertically at the junction. A minor fault passes through block 1 (see map). I was unable to trace it southwards through block 2, since the structure is obscured by alluvium.

The Pegu beds of this area are probably entirely marine, no brackish water shells or other evidence having been found to indicate an estuarine type. Dark-coloured shale beds preponderate, and selenite is scarce. The Irrawadi beds are frequently hidden by a covering of Red Silt on the high ground. In the valley of the Pin Chaung, this alluvium has been denuded, and Irrawadi beds are well exposed. Red Silt is found covering the Pegu outcrop. It is now being again denuded.

**Prospects of oil.**

The chances of oil in the Gwegyo hills have been already discussed by Pascoe. His remarks apply with equal force to this area in which three wells have been drilled on the crest in block 5; two have been drilled close to the boundary-fault in block 1, and three near Tetma in the north of the Gwegyo hills. The results, I think, have proved that this field cannot be made to pay, since the oil occurs in too small quantity. If the fault-rock has partially plugged the oil-sands, small quantities of oil, but most probably not sufficient to pay, may be reasonably expected in wells drilled immediately west of the boundary-faults. Again, oil might be looked for along the remnant of the crest in block 5; here, however, it has been shown that the crest is sinking, hence the oil-sands would probably be too poor to pay.

# THE SILVER-LEAD MINES OF BAWDWIN, NORTHERN SHAN STATES. BY T. D. LATOUCHE, B.A., F.G.S., *Superintendent, Geological Survey of India,* AND J. COGGIN BROWN, B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 12 to 24.)

## I.—GEOLOGY.

### By T. D. LaTouche.

**Introduction. History of the mines.**

THE existence of rich ores of silver and lead in the Northern Shan States has been known for many years. In the accounts of the various missions to the Court of Ava, from that of Michael Symes, in the year 1795, to that of Sir A. Phayre, who was accompanied by Dr. T. Oldham, Superintendent of the Geological Survey, in 1855, reference is made to these mines, but no Europeans were allowed to visit them, and even so late as 1895, when the sixth edition of the quarter inch Topographical Survey map was compiled, so little was known of them that their position is not marked.

A very high antiquity has been ascribed to the Bawdwin mines. Mr. C. H. Henniker[1] says that work probably commenced there over 1,000 years ago, but gives no authority for the statement. The first authentic record of the mines is found in an inscription, discovered at Bawdwin and translated for Mr. Maclaren, late Specialist, Geological Survey of India, by Mr. Taw Sein Ko, the Government Archæologist, Burma. According to this inscription, work was commenced at Bawdwin by the Chinese in the 9th year of the Emperor Ch'ingtsou (Yonglo) of the Ming dynasty. This date would correspond to 1412 A. D.[2] The first mention of the mines to be found in a European work is by Symes in 1795, who calls the place Badouem, and says that it is six days' journey from Bamoo (Bhamo) near the frontiers of China.[3] Crawford, in 1827, estimated the production of the mines at 960,000 ticals or £120,000 sterling annually, and was informed by two Chinese merchants, who had been to the place, that about

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1 Mining Journal, Vol. LXXIX. p. 52.
2 J. Malcolm Maclaren. *MS. Report*, 1906.
3 Symes, *Embassy to Ava*, p. 324.

1,000 miners were employed and that the tax paid to the King of Ava was 4,800 ticals, about £600 sterling. He places the locality, which he calls Bor-twang, at 12 days' journey from Bhamo, towards the Chinese frontier.[1]

At the time of Sir A. Phayre's mission, in 1855, Dr. Oldham[2] says that the tax paid to the King of Ava was only 40 ticals per annum, but it was stated that 10,000 Chinese were employed, a number that was probably greatly exaggerated, if one may judge from the evidences of their occupation that now remain at Bawdwin. The reduction in the amount of revenue received by the King of Ava seems to indicate that the production of the mines had greatly fallen off since Crawford's time.

At about the time of Sir A. Phayre's visit to Ava the Panthay rebellion broke out in Yunnan, and taking advantage of the unsettled state of the country, the Kachins of the northern hills began to advance southwards, rendering the position of the Chinese at Bawdwin very precarious. It may have been at this time that the extensive lines of entrenchments, which can still be traced along the ridges and spurs of the hills surrounding the mines, were constructed. A further cause for the decline of the industry which now took place must have been the increasing difficulty of procuring fuel and supplies and of extracting the ore as the galleries approached the level of the stream flowing through the valley, in the absence of more efficient appliances for dealing with the increasing influx of water than were possessed by the Chinese, and the mines were finally abandoned by them about the year 1868.[3]

After the departure of the Chinese the Burmese Kings Mindun Min and Thebaw made several attempts to work the mines, but owing to the ravages of disease and the want of metallurgical knowledge these efforts resulted in failure.

I have been informed by Mr. C. A. Freymuth, who was one of the first Europeans to visit the mines on behalf of the syndicate formed to reopen them, that on his arrival he found a number of Kachins employed in smelting portions of the slag

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1 Crawford, *Journal of an Embassy to the Court of Ava*, pp. 427, 444.

2 Captain H. Yule, *Narrative of the Mission to the Court of Ava in 1885*, p. 345.

3 I am indebted for much of the information regarding the history of the mines to Dr. J. Malcolm Maclaren, who was the first geologist to visit the mines, in 1905.

heaps left by the Chinese. For this purpose they picked out the richest fragments of slag, containing 50 or more per cent. of lead, and smelted them with a large excess of charcoal in the small furnaces shown in Plates 16 and 17. The furnace was filled with the mixture of ore and charcoal, and then covered over with a heap of earth and turf. It was then lighted from below, and the metal, percolating through the mass, collected in a hollow beneath the furnace, and was ladled out into moulds.

Within the last few years interest in the mines has been revived by the discovery that the Chinese worked them principally for the sake of the silver contained in the ore, and threw away the bulk of the lead in the form of slag, huge heaps of which now mark the sites of their smelting furnaces. A Company has been formed with the object of collecting and smelting this slag, and has been engaged in constructing a tramway from Manhpwi, the nearest station on the Northern Shan States railway, to the site, in order to bring away the material and smelt it at some more convenient spot.

Up to the present time the Company has confined its attention to the slags lying on the surface, but it should not be forgotten that, below the water level, there may still remain bodies of ore untouched by the Chinese miners, and it is to be hoped that as soon as the present scheme is in working order the ground will be thoroughly prospected with modern appliances.

**Situation and physical aspect of the locality.**

The mines at Bawdwin[1] are situated close to the northern border of the State of Tawng Peng, in approximate latitude 23° 6′ 45″, longitude 97° 20′ 30″, on the banks of a small stream called the Nam-pang-yun,[2] a tributary of the Nam Tu (Myitnge of the Burmese). For several miles round this spot the hills are almost entirely denuded of trees, but are thickly covered with grass (Pl. 12). This absence of tree jungle in a country generally so thickly wooded gives the district a peculiar aspect, as seen from the surrounding heights, and is probably partly due to the destruction of the forest for fuel, and partly to the fumes from the smelting furnaces, for the Chinese apparently

[1] Burmese = *Silver mines.* These mines are also known as Bawdwin-gyi, the great silver mine.

[2] Shan = *The Stream of the peacock camp.* Probably in allusion to the brilliant blue and green films of copper ores spread over the rocks at several places in the gorge.

made no attempt to collect the products of volatilisation, which were discharged directly into the atmosphere. Since the desertion of the mines little change in this respect has taken place, but bamboos are springing up in the ravines, and a few scattered trees on the hillsides, and in time, if left alone, they will no doubt become as well-wooded as before.[1]

The mines lie several miles beyond the northern edge of the Burma Survey sheet No. 331, on the one inch scale, and the only map of the neighbourhood available is the quarter inch sheet No. 4 N. W., which is by no means accurate. Moreover, the country for several miles to the south of the mines is quite uninhabited and covered with dense jungle, without paths, in consequence of which it was impossible to follow up the formations found to the south continuously into the Bawdwin area. Some doubt exists, therefore, with regard to the exact position of some of the Bawdwin rocks.

The general sequence of rocks to the southward is the following:—At a variable distance of two to five or six miles to the west of the Nam Tu, which in this part of its course runs almost due north and south through a deep gorge, is found an ancient land surface, composed of slates, quartzites, and grits of pre-Ordovician age, along the eastern border of which rocks of Ordovician, Silurian, and Devonian age were deposited in succession. These rocks have been traced northwards from the neighbourhood of Hsipaw, forming a broad belt along the valley of the Nam Tu. Along the outer or western edge of this belt Silurian grits and sandstones (Namhsim beds) are found resting directly upon the upturned edges of the rocks forming the old land surface, with a very irregular boundary, deeply eroded by the tributaries of the Nam Tu.

Near the base the Silurian beds consist of coarse felspathic grits, frequently pebbly, which are succeeded by finer sandstones as we recede from the old shore line, and finally by fine grained sandy marls. They overlap the older Palæozoic or Ordovician beds, in such a manner that the latter are only visible at a considerable distance from the shore line, where they happen to have been brought to the surface by subsequent earth

[1] I am informed by Mr. J. Coggin Brown, who visited Bawdwin with me and has since travelled in Yunnan, that this denudation of the forests is an invariable accompaniment of Chinese occupation and is not confined to the neighbourhood of localities in which smelting is carried on.

movements. The Ordovician beds consist of shales, marls, and limestones, usually very rich in characteristic fossils, and are known locally as the Naungkangyi beds. At the top of them, immediately beneath the Namhsim sandstones, is found a thin but persistent band of shales, the Panghsapyé graptolite band, containing *Graptolites* of Llandovery types, resting upon a band of purple calcareous shales, which latter represent the purple Hwe Mawng beds of the ranges between the plateau and the Salween to the south-east of Lashio. The Namhsim sandstones are succeeded above by the limestone of the plateau, of Devonian or Carboniferous age, which does not extend to the west of the Nam Tu in the southern part of the area, but crosses it at the mouth of the Bawdwin river, or Nam-pang-yun.

The chief structural feature in this belt of rocks is a great overthrust, which has been traced almost continuously from south to north from Panghsapyé (22° 42′ 30″: 97° 17′) to Bawdwin, a distance of about 30 miles, running parallel to the Nam Tu for the greater part of its course. Along this overthrust the Naungkangyi beds have been pushed up westwards over the Namhsim sandstones, so that a broad belt of the former intervenes between two areas occupied by the sandstones, the latter to the east being found in their normal position under the Plateau Limestone, and forming a precipitous scarp along the left bank of the river, with the graptolite and purple bands at its base; while to the west the sandstones dip beneath the Naungkangyi beds along the plane of the fault (see section, Plate 24, fig. 1).

Near the boundary of sheet 331 the fault appears to take a north-north-westerly trend, and, leaving the band of Naungkangyi shales, traverses the floor of older rocks underlying the Naungkangyis in the neighbourhood of Bawdwin (see map, Pl. 23). These older rocks consist here mainly of coarse felspathic grits and rhyolitic tuffs with thin flows of true rhyolite (first detected by Mr. Maclaren), succeeded above by finer grained reddish brown sandstones, not easily distinguishable from the Namhsim sandstones to the south, but without fossils. The standstones are found extending for some four or five miles along the gorge of the Nam-pang-yun below Bawdwin, with a regular easterly dip, until they disappear beneath the Naungkangyi shales. The overthrust passes through the felspathic grits at Bawdwin itself, and there is no

doubt that the mineralisation of the rocks of that area is due to the intense crushing and dislocation of the rocks caused by it. In addition to the grits there are found in the immediate vicinity of Bawdwin patches of quartzitic sandstones and shales, with which is associated, some miles to the west of the mines, a band of coarse conglomerate. It is extremely difficult to make out the relations of these beds with the grits and rhyolites, but the probability is that they are outlying patches of the Namhsim sandstone series, folded or faulted down among the older rocks.

A minor line of disturbance of the same nature as the principal overthrust appears to branch off from the latter at Bawdwin, and, taking a more southerly course, passes between the Trigonometrical Survey peaks 5,550 feet and 5,834 feet in the neighbourhood of Manglang (22° 18′: 97° 20′ 30″) to the south of which it seems to die out. The most intense amount of dislocation and crushing has therefore taken place at Bawdwin, where these two lines unite. Over a broad zone parallel with the plane of overthrust, through which the Nam-pang-yun has excavated a deep narrow gorge, the crushing has been of the most intense description, and the shear planes and fissures thus produced have afforded an easy passage for the mineralising agencies from below (see section, Plate 24, fig. 2).

**Petrology.**

The rhyolites of Bawdwin exhibit the usual phenomena observed in acid glassy lavas, such as flow, sphærulitic and perlitic structures, and corrosion of the quartz phenocrysts. The ground-mass is always crypto-crystalline, and sometimes exhibits the peculiar structure of alternate light and dark areas under crossed nicols known as a 'quartz mosaic.' This structure is exactly similar to that which occurs in some of the Malani rhyolites of Western Rajputana,[1] and in both instances the quartz phenocrysts are surrounded by a 'court' or closed area, the quartz of which is in optical continuity with that of the phenocryst, and extinguishes simultaneously with it under crossed nicols. The Malani rhyolites are of pre-Vindhyan age, but Mr. Fermor[2] has shown that the same structure occurs in the lavas of Pavagad hill, in the Panch Mahals,

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[1] T. D LaTouche, Geology of Western Rajputana, *Mem., Geol. Sur. Ind.*, Vol. XXXV, Pt. 1, p. 83.

[2] On the lavas of Pavagad hill, *Rec., Geol. Sur. Ind.*, Vol. XXXIV, Pt. 3, pp. 154, 160.

Bombay Presidency, and that those lavas are intercalated with the Deccan trap, and are therefore of late Cretaceous (Maestrichtian) age. The presence of this structure cannot be taken, therefore, as evidence of a similarity in age between the Bawdwin and Malani rhyolites, but in other respects, such as the preponderance of quartz phenocrysts over those of felspar, the absence of plagioclase felspar, and of augite, they resemble each other and differ from the lavas of Pavagad hill, as described by Mr. Fermor. Since the Bawdwin rhyolites are certainly pre-Ordovician, there is probably not very much difference in age between them and the Malani rocks.

The tuffs, which form by far the greater part of the bulk of the rocks at Bawdwin, the flows of true rhyolite being exceedingly thin and of rare occurrence, resemble the latter superficially under the microscope, but are distinctly clastic in origin, and sometimes contain fragments of the lavas, in which I have detected, in one or two instances, examples of the 'quartz mosaic' structure referred to above.

With these are associated beds of quartzite, shales, and sandy grits, in a few instances coarse grained and even pebbly; but the geological structure is so complicated that, in the absence of an accurate map on a large scale, and in the short time at our disposal, it was found impossible to work out the details of the structure.

**Mode of occurrence of the ore.**

The ore occurs in the form of nodular masses of finely crystalline galena, associated also with zinc blende, in which specks of copper pyrites are disseminated, and as granules impregnating the felspathic grits, in which, as Mr. Coggin Brown observes, it appears to have replaced the felspar. No ore was found in any of the adits left by the Chinese miners, who appear to have worked it out entirely so far as they could reach it, but the nodular masses were found in a section exposed by a slip, or perhaps an old quarry, at the upper end of the Bawdwin gorge (point B on map). Here they are imbedded in the grit, apparently coinciding with the bedding planes, but the country rock is in so rotten a state that it is difficult to make out the original bedding. The largest mass found here actually *in situ* measured about 2 feet 6 inches by 1 foot. Along the zone in which the nodules occur the grits are also

strongly impregnated with galena. They are also traversed by thin films of copper ore, azurite and malachite, deposited along the joint planes. The rotten state of the surrounding rock appears to be due to the formation of soluble sulphates and carbonates. There are no regular veins containing layers of the various minerals arranged in a definite order, and several of the minerals usually associated with galena, such as fluor spar and calcite, are absent. Strings and nests of white quartz are frequently to be found in the disturbed zone, but appear to have had no close connection with the development of the ore. Beds of massive barytes are also of common occurrence, but they were not found in direct association with the galena. In one spot (C on map) the barytes occurs in considerable quantity, in fragments up to a foot in diameter, scattered over the surface of a knoll over an area of two or three hundred square yards, and evidently derived from the outcrop of a large mass. A number of other minerals of secondary origin are found in association with the ores, and will be dealt with by Mr. Coggin Brown.

**The mines.**

Most of the old Chinese adits at Bawdwin are situated in a narrow gorge of the Nam-pang-yun, at a point where it runs from north to south parallel and close to the zone of dislocation of the strata. The sides of the gorge, especially the eastern, on which side the greatest amount of disturbance has taken place, afforded a ready means of getting at the ore bodies by driving horizontal or slightly inclined adits, obviating to a great extent the necessity of getting rid by artificial means of water draining into the mines. Some of the excavations descend below the level of the stream, and are now filled with water, but it is probable that none of them extend to any great depth. Others were driven almost vertically upwards either to afford ventilation or to follow up rich bodies of ore, and were ascended by steps cut in the rock. It is probable that one at least was driven right through the hill into a narrow ravine (E on map) to the east (hereafter referred to as the Eastern Ravine), where there are abundant traces of the ore having been washed from the angular talus with which the bed of the ravine is strewn, and as there were no furnaces here, it is evident that the ore so collected was taken into the Bawdwin valley to be smelted. The central portion of this gallery, however, passes through very bad ground and

a good deal of the roof has fallen in, so that at present it is unsafe to traverse its whole length, though a fairly strong current of air passes through it, and it is evidently open all the way.

Very little timbering seems to have been used by the miners. Indeed in most cases it was hardly necessary, because of the form given to the galleries, which are always arched at the top, and in bad ground are of an oval shape. They were so well designed that even now, after many years of neglect, many of them may be traversed in perfect safety. When the mines were first re-visited a few years ago, some of the galleries were found to be filled more or less with a sedimentary deposit of oxide of iron in a semi-fluid condition.[1] There was surprisingly little water to be found in them at the time of our visit, but no doubt the influx would be greater during the rainy season. In one case at least means had been taken to drain off the water by cutting a trench alongside the foot-way of the gallery, and in another arrangements had apparently been made for ventilation by means of pipes, possibly bamboos, for a continuous recess had been cut along the side of the gallery at about a foot above the floor, ending at the entrance in a circular hole cut through the rock at the side. The galleries vary in height from about 3 feet to 5 or even 6 feet, and are usually well proportioned. At times they expand into irregular cavities, evidently places where large bodies of ore had been met with. This again indicates that the ore did not occur in regular lodes, but in masses or 'bodies' of irregular shape and size. There appears to have been no definite system of levels and headings, and in some cases one gallery has broken through, seemingly accidentally, into another, but on the whole one was very favourably impressed by the excellence of the methods employed, especially when contrasted with the burrows, often not much larger than a fox's earth, which one is accustomed in India to associate with any mention of native mining. Some of the ore seems also to have been extracted from open quarries, some of which are of very large dimensions, like that shown in Pl. 13.

The mines extend along the course of the stream for a distance of about 3 miles to the point marked D on the map,

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[1] C. H. Henniker, *Min. Journal*, Vol. LXXIX, p. 52.

above which the banks are too far from the zone of disturbance to admit of the ore being reached in this way.

**Future prospects.**

Since the area worked by the Chinese was limited to that which could be reached without much difficulty from the sides of the gorge of the Nam-pang-yun, and downwards by the distance to which they could sink without being met with too great an influx of water to be dealt with in the absence of mechanical appliances, it is worth considering whether there is not still a large amount of ore left, which could be extracted profitably with a modern mining equipment. I see no reason to suppose that such is not the case, and that if the ore is found on assay to be sufficiently rich in silver and lead, a profitable mining industry should not be established again at Bawdwin. There is no reason to suppose that the overthrust, which has permitted the rocks to be impregnated with minerals, does not extend much further to the north, or that the rocks affected by it have not been mineralised in that direction. On the contrary, I am informed that the Chinese worked another locality to the north of Bawdwin, and that the traces of their activity are of the same description as at that place. In any case I think that the country should be adequately prospected, but in order that this may be done an accurate map is absolutely necessary, for the present ¼-inch map, which is the only one available of the country between this and the Chinese frontier, is most unreliable and even misleading.

In order to reach the ground left unworked by the Chinese at Bawdwin, shafts would have to be sunk, either in the Bawdwin ravine or in the Eastern Ravine, or in both, and levels driven from them into the zone of disturbance. Shafts sunk in the Eastern Ravine would have this advantage, that as the overthrust plane is inclined in this direction, there would be a less distance of dead ground between the shafts and the ore-bearing zone to be passed through. The water discharge on this side also would probably be less, though I do not think that it would be great in any case.

**Chinese methods of treating the ore.**

Sufficient remains are left of the old furnaces and other appliances of the Chinese to enable us to form a fairly correct idea of their methods of treating the ores

and extracting the silver. The ore after being washed and dressed as described below, was smelted in the large furnaces (Plates 14 and 15). These were placed in convenient positions on the hillsides at some distance above the bed of the stream, so as to allow plenty of room below them for dumping the slag. The furnace is of simple construction, consisting of a concave fire-clay bed or hearth of circular or oblong shape, sloping from back to front, where it is narrowed, imbedded in a mass of clay concrete built up inside a wall of stone or large bricks. The hearth was heated from beneath by three flues, the roof of which was supported by rods of fire clay, radiating from the back of the fire hole. The ore was mixed with charcoal, of which a considerable quantity is still left in the slag. As the reduction proceeded the lead ran down to the front of the hearth, and, percolating through the mass of fuel and ore filling the front of the furnace, collected in a hollow beneath the flues.[1]

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[1] Note by Mr. Coggin Brown.—It is interesting to note that this type of furnace differs considerably from the one in use amongst the Chinese in Yün-nan at the present day. The latter is a true blast furnace usually from 8 to 10 feet high, with a roughly square shaft in which the reactions take place. After a very thorough roasting of the lead ores, they are smelted with charcoal in furnaces of this type, the reduction being brought about by means of a blast which enters the furnace near the bottom, and is produced by a cylindrical blower of the ordinary Chinese pattern worked generally by a water turbine. The molten lead is tapped from time to time from a hole in the lower part of the side of the furnace, whilst the slag flows out continually through a slag-hole in the front.

This method is a true "Roast and Reduction" process. A careful study of the remains of the Bawdwin furnaces has led to the belief that the method used there belonged rather to the class of "Roast and Reaction" processes, for the furnaces are of an open hearth-like type, and do not appear to have been fitted with any contrivance for producing a blast. Such open furnaces would be more suited for the smelting of the lead minerals of this particular district. After washing and concentrating the ores, at both of which processes the Yün-nanese are very expert, a high grade material was doubtless ready to commence with. This in the case of the Bawdwin ores was in all probability a mixture of lead sulphide and sulphate, as galena and anglesite.

This mixture, which may have been submitted to a preliminary roasting, was now mixed with charcoal, the purpose of which was to serve as fuel and also to help in the reduction of a part of the sulphide: and then treated in the furnaces described above. The temperature at first would be kept low so as to bring about an oxidation of the sulphide into sulphate and oxide, and later would be raised so as to cause these compounds to react on the unaltered sulphide, resulting in the production of metallic lead and the liberation of sulphur dioxide.

That such is probably the true interpretation cannot be doubted after an inspection of the furnace remains, which belong to the hearth-like group suited for these reactions, and are not of the shaft type fitted with tuyers for blowing.

The composition of the slags lends strong confirmation to this view, for they contain upwards of 47 per cent. of lead, which might easily be obtained in a "Roast and Reaction" process, but would not result from a "Roast and Reduction" treatment in a blast furnace.

The smaller furnaces (Plates 16 and 17) were, it appears from what I have been told by Mr. Freymuth, built by Kachins after the departure of the Chinese, in order to smelt the lead remaining in the slag. The design was apparently copied from the original Chinese furnaces, but they are built on a much smaller scale. The method employed in smelting has been described on page 237.

Where the ore was much mixed with gangue, or disseminated through the grit, it was pounded up in mortars, about a foot in diameter, one of which is seen in the foreground of Pl. 19, hollowed out of solid pieces of grit or sandstone, and then washed. A piece of ground in a convenient spot, where water was easily available, was levelled, and at one side one or two shoots, sloping at an angle of 30 to 40 degrees, and paved with flat stones, were constructed. Beside the floor a tank 8 or 10 feet square and about 2 feet deep was built for holding water. The crushed ore was heaped on the levelled space and was gradually washed down the shoots with water thrown from the tank, the lighter material being carried away in the rush of water, while the heavier ore was left behind (Pl. 18).

These floors were also used in separating ore from the talus of sandstone fragments filling the bottom of the ravine, and extend down the valley for nearly a mile below the mines.

The lead was cupelled in beehive shaped furnaces (Pl. 20, fig. 2), several of which are left in a very good state of preservation. The measurements were taken from one of a row of twelve, built against the hillside near the left bank of the stream. These round furnaces appear to have been used for a preliminary extraction of the silver, the final purification being effected in the square furnace (Pl. 19, and Pl. 20, fig. 2). Two of these remain, and were evidently considered to be of more importance than the others, since they are enclosed in a solid stone building which was probably roofed over. Outside the door of this is a stone table on which the silver may have been weighed and packed for despatch.

In addition to these furnaces the remains were found of two or three small blast furnaces of the ordinary native type. These were apparently used for assay purposes. Close to one of them I picked up a sandstone mortar which could only have been used

for crushing very small quantities of ore as it is only about 3 inches in diameter.

**Copper ores.**

The Chinese do not appear to have made any use of the copper contained in the ore, and it is in such small quantity that it probably would not repay the expense and labour of smelting it in any case. They, however, extracted and smelted a small amount of copper ore near the village of Loi Mi, about 3 miles west of Bawdwin, where several heaps of copper slag are still to be seen. The excavations here are very small in extent and were evidently made for prospecting purposes only. Similar heaps of copper slag and small excavations are to be seen near the head of the Nam-pang-yun, west of the Bawdwin mines.

## II.—THE ORE DEPOSITS AND SLAGS.

### By J. Coggin Brown.

**Introduction.**

Mr. LaTouche has already given an account of the geology of the district around the Bawdwin mines. He has also dealt with the history of the Chinese occupation there, and has described in detail the methods then used in winning and smelting the ores. I accompanied Mr. LaTouche to Bawdwin in February 1907, and had then an opportunity for examining the ore-deposits and for collecting minerals, as far as circumstances would permit. These notes are based on observations then made and on the results of the examination of the specimens collected.

**Limits of investigation.**

At the present time it is not possible to make a thorough study of the ore-deposits. The whole area has certainly been well opened up by the very extensive mining operations conducted there in the past, yet owing to the collapse of the old workings but little can be learned from them now. Some of the adit levels have been re-opened by the Great Eastern Mining Company, and found to be constructed with no small degree of engineering skill, and to extend sometimes for considerable distances. I have examined most of these and have come to the conclusion, both from their large size and also from the absence of ore in them, that they

represent the travelling-ways or haulage-roads of the mines rather than the actual workings in the ore-bearing strata themselves.

Attempts were made to enter the smaller workings in the hope that ore might be discovered *in situ* there, but owing to the decomposed condition of the rock, and the consequent danger of being crushed by falls, these had to be abandoned. There are, however, various ore-bodies which have not been worked to any extent by the Chinese and which crop out on the sides of the gorge. In such positions the ores have become very generally oxidised, both from exposure to the air and from secondary alteration by surface waters, and consequently the true interpretation of their original condition is somewhat interfered with. Any conclusions which may be arrived at in these notes are therefore not to be regarded as final, for the many problems which present themselves in questions of this kind can only be definitely solved after a detailed examination and careful study of the whole of the underground structure of the area has been made.

**Limits of the Chinese mining operations.**

As defined by the limits of the ancient Chinese workings, the metalliferous area at Bawdwin is a well marked one. Practically the whole of their mines are confined to the north of the main stream, which is known to the Shans as the Nam-pang-yun and has been re-named the Sterne River by one of the European companies holding the mining rights for the district. The ore-deposits have been worked from both sides of the hill which lies between this river and its tributary stream in the E. R. valley; the Chinese miners taking full use of the advantages offered them by the narrow gorge-like valleys in the construction of their levels.

**Extent of ore-bearing ground.**

As thus defined by the extent of the ancient workings, the ore-bearing ground is comprised in an area about 1½ mile long and between ¼ to ½ mile broad at its wider parts. This area comes entirely within the Bawdwin Grit and Rhyolite group of Mr. LaTouche.

The immense amount of material which has been taken from this ground in bygone days is only realised after seeing the number of adits which have been constructed (about 300 old open-

ings—tunnels, shafts, and open workings—are said to have been counted by the engineers of the present Company), the remains of furnaces scattered over different parts of the valley, and the great heaps of slags which bear eloquent testimony to the quantity of ore smelted.

A melancholy confirmation is added by the large graveyards which cover the hillsides in some places, and bear witness to the heavy toll exacted both by the climate, and the deadly nature of the work, from the numerous ranks of the miners.

**Accessible ore-bodies.**

There are places where ore can be seen *in situ* exposed "to day," which for some reason have not been extensively worked by the Chinese. The ore-bodies all crop out on the hillsides to the north of the Platform. Whilst at the mines I was unaware of the fact that names had been applied to these different localities, but from the map which accompanies a manuscript report by Mr. Maclaren I have been able to make them out as the Jail, Maitland, Doormouse, and Amphitheatre workings.

**Mode of occurrence of ore.**

The ores which can be seen in these consist chiefly of galena and zinc blende, associated sometimes with small amounts of iron pyrites and chalcopyrite.

Other minerals, as anglesite, cerussite, malachite and azurite, derived in all probability from the sulphide ores, are fairly common in some of these open workings. The ores do not occur in veins or lodes, but as impregnations in bands of the country-rock, which usually consists of a coarse rhyolitic tuff which contains small rock fragments and a good deal of quartz. Occasionally only a small amount of the sulphides is seen distributed in an irregular manner through the rock. At other places, as in the Upper Maitland area, the ore-bearing band varies from 1 to 2 feet in thickness and consists largely of galena and zinc blende; the country-rock being sometimes entirely impregnated with these minerals.

The largest open workings are those of the Amphitheatre, but this great excavation, which forms a feature of the landscape for miles around, has doubtless been partially formed by landslips (Pl. 13).

**Ores mined by Chinese.**

It is difficult to understand why the ancient Chinese workers, who honeycombed the Bawdwin mineralised area above water level with a perfect labyrinth of levels, cross-cuts, stopes and shafts in search of ore, should have left unmined these ore-bodies which crop out on the hillside, and which certainly contain much argentiferous galena. The only reason seems to be that the unusual amounts of zinc ores here associated with the galena presented to them difficulties in smelting which could not be overcome. This naturally leads one to suppose that the ore which was mined in the underground workings may have been different from that now seen in these open air exposures, and may possibly occur in some other manner, but this must remain an open question until further development has taken place.

**Metamorphism of the country-rock.**

It is very difficult to say what the petrological characters of the unaltered country-rock were, owing to the intense dynamic metamorphism which has taken place in the vicinity of the ore-bodies, and which has led not only to a mechanical effect in smashing up the rock and so rendering it permeable to mineralising solutions, but has also been the cause of important mineralogical changes.

I am, however, inclined to believe that the rock originally was a coarse rhyolitic tuff containing a large percentage of rock fragments. Felspathic grits, quartzites and thin bands of true rhyolites are all found in more or less direct association with the tuff beds themselves. The grits especially have been affected by the general mineralisation which has taken place.

**Production of a quartz-felspar mosaic.**

Very often the entire rock has been so altered that it now consists largely of quartz grains set in a mosaic of quartz and felspar, giving it in hand specimens the appearance of a fine-grained grit. Under the microscope, the mosaic is often almost crypto-crystalline, but sometimes it is developed on a larger scale, and each unit is seen to be quite homogeneous and fitting into the inequalities of its neighbours. In other sections after the total replacement of a felspar crystal by galena, it is often noticed that there are thin minute crystals which have not been replaced and which pierce the pseudomorph in all directions. These

appear to be muscovite formed by the metamorphism of the felspar, before the mineralisation of the rock. The felspar would be much more liable than the more stable mica to be attacked and replaced by the galena.

**Formation of the ores.**

As far as the open workings of the Upper Maitland district are concerned (from which all the specimens here referred to came), the manner of formation of the ores was essentially a process of metasomatic replacement of the minerals of the country rock by metallic minerals probably carried in solution. The galena and other sulphide ores, zinc blende, pyrites and chalcopyrite, attacked first of all the felspar in the rock. As the replacement went on the mosaic-like ground-mass gave way to the sulphides, and finally the quartz grains themselves were partially or entirely replaced.

Specimens can therefore be found, showing only a very small proportion of the original minerals replaced by sulphides, through others composed of sulphide ores and a large amount of quartz, to those which consist almost entirely of sulphides with very little quartz. The microphotographs on Plates 21 and 22 are intended to show examples of these structures. Plate 21, fig. 1, shows a thin section of a typical Bawdwin rhyolite (slide No. 5849 G. S. I. collection), exhibiting flow structure. Fig. 2 of the same plate shows the almost complete replacement of the minerals of the country rock by galena (slide No. 6734 G. S. I. collection). On Plate 22, fig. 1 (slide No. 6732), is given a representation of a partial replacement by galena and fig. 2 (slide No. 6735) is intended to show the commencement of the replacement of the ground-mass of the rhyolitic tuff by the same lead mineral.

**Remarks on the ores.**

The ores found in the open deposits consist as a rule of galena and zinc blende associated with small quantities of iron and copper pyrites. As a rule, if copper pyrites is present with the galena, the amount of zinc blende is much less. All the sulphides except zinc blende have been found occurring alone in small amounts.

**Order of deposition of the sulphides.**

As regards the order of deposition of the sulphides, the microscopic examination of various specimens shows that iron and copper sulphides when present with the others were

the first to be deposited, for they have been found in grains surrounded by galena, the converse arrangement not having been observed. In the case of the lead and zinc sulphides, the relationships are somewhat ambiguous. Galena has been found surrounded by, and also surrounding zinc blende. The latter is by far the commoner case, and it may be assumed that as a general rule the zinc blende was deposited prior to the lead sulphide. In most of the sections which were examined the two sulphides of lead and zinc occur in small grains scattered indiscriminately through the rock. It is remarkable, however, that in some instances the sulphides are seen to be growing more or less separately, giving the ore a banded appearance under the microscope.

**Occurrence of oxidised ores.**

The oxidised ores malachite and azurite are found filling cracks and small shear planes in the metamorphosed rock. They do not appear to replace any particular mineral. Anglesite and cerussite are often found in cavities in the galena-bearing rock, evidently close to the mineral from which they have been formed.

It must not be inferred from these brief remarks on the order of formation of the ores that the deposition of any one particular mineral over a large area went on for a certain period and then ceased, to be followed by the deposition of another. In all probability the deposition of all the minerals was proceeding in different places at the same time, and the order copper and iron pyrites, zinc blende and galena represents broadly the general rule for deposition only with respect to the area from which the specimens examined came.

**Cause of the metamorphism.**

Mr. LaTouche has shown that the intense metamorphism of the grits at Bawdwin in which the ore-deposits occur is due to reversed faulting. To quote his words: "Owing to the two lines of faulting which unite there the most intense amount of dislocation and crushing has taken place. Over a broad zone parallel with the plane of the overthrust through which the Nam-pang-yun has excavated a deep narrow gorge, the crushing has been of the most intense description and the shear planes and fissures thus produced have afforded an easy passage for the mineralizing solutions."

**Analogy of the Mount Lyell Copper-field in Tasmania.**

Professor J. W. Gregory, F.R.S., has recently shown how the distribution and origin of the ores of the Mount Lyell Copper-field in Tasmania is entirely due to the fault system there. A great overthrust connected with a series of parallel cross faults and thrust planes has crushed the local schists and rendered them permeable to solutions containing copper and iron, with some gold and silver salts in solution, which Professor Gregory thinks rose along the great Mount Lyell fault.[1] The theory of the origin of the Mount Lyell ores is practically identical with that advanced by Mr. La Touche to account for the ores of the Bawdwin metalliferous area.

## The more important minerals found at Bawdwin.

**Galena.**

Lead sulphide, PbS, is usually found disseminated in irregular-shaped grains in the country rock. The grains vary in size from a few millimeters in diameter to large aggregations of the mineral. It has been shown previously that the galena has metasomatically replaced the minerals of the rock in which it is found. When this replacement is practically complete the lead ore becomes massive and compact, whilst the broken surface of a freshly fractured specimen exhibits a glittering appearance due to the brilliant cubical cleavage-planes.

Sometimes the separate disseminated particles exhibit a distinct crystalline form and show the cubical cleavage well.

Galena. associated with zinc blende and other minerals, is found in all the open-air workings at Bawdwin, more especially in those of the Jail and Upper Maitland areas. Argentiferous galena doubtless constituted the main product for which the mines were worked in ancient times. A picked specimen of the galena-zinc blende ore from the Upper Maitland area assayed in the laboratory of the Geological Survey of India by Mr. T. R. Blyth was found to contain 47·87 per cent. of lead, a little zinc, traces of gold, and 87 ozs. 14 dwts. 4 grs. of silver to the ton of lead.

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1 "The Geological plans of some Australian Mining Fields" by J. W. Gregory, F.R.S., Science Progress, Vol. I, p. 117.

The galenas of the Shan States and of the neighbouring province of Yün-nan in China appear as a rule to be very rich in silver, as the following analyses show:—

*Amounts of silver in picked specimens of galena from the Shan States and the Province of Yün-nan (in Western China).*

| LOCALITY. | AMOUNT OF SILVER. Per ton of lead. | | | Analyst. | Collector. | Date. |
|---|---|---|---|---|---|---|
| | ozs. | dwts. | grs. | | | |
| Bawdwin . . . | 87 | 14 | 4 | T. R. Blyth | J. Coggin Brown. | 1907 |
| Kyet You (in Yün-nan) | 104 | 10 | 6 | A. Tween | Dr. J. Anderson. [1] | 1870 |
| Ponsee (Kachin Hills) . | 73 | 10 | 0 | Do. | Do.[1] | 1870 |
| Kakhyeen country . . | 63 | 14 | 8 | Do. | Dr. Clement Williams[2] | 1863 |

**Lead sulphate, $PbSO_4$. Anglesite.** Anglesite is a common mineral at the mines, but is especially abundant at the Upper Maitland workings, where beautiful crystals can be obtained.

The usual form assumed by these crystals is that of a simple orthohombic prism, elongated somewhat along the vertical axis, and generally terminated by pyramidal faces. Many of the crystals are by no means so simple as this, the pyramidal faces being especially liable to a variety of combinations which cannot be deciphered without crystallographic measurement. Tabular crystals, formed by growth parallel to the C axis are of rare occurrence, whilst a massive variety is sometimes found in small quantity as a coating on galena. As usually found, the crystals are coated with a thin opaque film of a white substance, which being at once removed by dilute acid may consist of lead carbonate. All the specimens collected are quite colourless, and are often transparent, whilst their brittleness is especially noticeable; generally they

[1] Geology of India, Pt. 3, Economic Geology, by V. Ball, 1881, p. 237.
[2] Through Burmah to Western China, by Clement Williams, 1868, p. 31.

possess an adamantine lustre, but crystals with a duller and more vitreous lustre have been noticed.

Anglesite was probably mined by the Chinese; it is certainly of economic importance at Bawdwin to-day.

**Cerussite.** Carbonate of lead, $PbCO_3$. This mineral is found at Bawdwin in association with anglesite and galena, and more rarely with malachite and azurite. It occurs in tabular orthorhombic crystals which often form penetration-twins. The crystals are usually tinged blue or green by salts of copper, but colourless specimens have been observed.

**Barytes.** Barium sulphate, $BaSO_4$. This is a fairly common mineral, but it has not been noticed in direct association with any of the sulphide ores. Mr. LaTouche remarks that "at one spot (C on his map) it occurs in considerable quantity, in fragments up to a foot in diameter, scattered over the surface of a knoll over an area of two or three hundred square yards and evidently derived from the outcrop of a large mass."

It has not been found as crystals, but occurs massive in coarsely grained aggregates, which are often full of small cavities. The broken surfaces of some of these masses show a platey structure with curved surfaces and a vitreous lustre.

Owing to the presence of cavities the results of determination of the specific gravity are liable to be slightly low. One specimen from the Amphitheatre gave a specific gravity of 4·4.

**Zinc blende.** Sphalerite, or Black Jack. Zinc Sulphide, ZnS. This mineral, which constitutes the chief ore of zinc, is common at Bawdwin, especially at the Upper Maitland and Jail workings, where it occurs associated with galena, and sometimes with galena, iron pyrites and chalcopyrite. It has been observed in massive bands of a blackish-brown colour, and granular lustrous appearance, this being probably due to the shining dodecahedral cleavage planes exhibited by each grain.

As a rule, however, it occurs with the galena in a much more intimate manner than this, the minerals being associated on a practically cryptocrystalline scale. The blende is then not usually recognisable until sections of the ore are examined under the microscope, when it is at once distinguished from the galena by

its semi-transparency and its brown colour. This somewhat unusual occurrence is readily understood when the formation of the minerals by metasomatic replacement is remembered.

The Bawdwin zinc blende appears to be much less liable to decomposition and oxidation than the galena with which it is found.

Up to the present, as far as is known no attempt has been made to extract zinc at Bawdwin, the position of affairs being strictly comparable with that in other parts of the world where similar associations of lead and zinc sulphides are found, and where very often in the past the lead ores alone have been smelted.

**Chalcopyrite.**

Copper pyrites, $CuFeS_2$. This mineral has been noticed in small amounts at the mines. It has not been found in crystals, but always occurs in small grains disseminated in the country-rock, generally accompanied by galena and iron pyrites. In many instances the grains are very small. The larger ones are of a brilliant brass-yellow colour when not tarnished.

With regard to the commercial importance of copper pyrites at the mines to-day it is not possible to offer any definite opinion until further exploratory work has been done, the information at present available being much too vague. It is stated by Sir George Scott in the "Gazetteer of Upper Burma and the Shan States"[1] that one or two mines were worked for copper alone.

Indications are not wanting that extended search would result in the discovery of other minerals containing copper and sulphur at Bawdwin.

**Pyrites.**

Iron disulphide, $FeS_2$. This mineral is not uncommon, and occurs widely distributed, being often accompanied by chalcopyrite. It usually occurs in small grains, but has been observed both in the massive and crystalline states. In one specimen, crystals of anglesite have grown on massive pyrites.

**Malachite.**

Basic cupric carbonate, $CuCO_3.Cu(OH)_2$. This carbonate of copper is noticed wherever copper ores are found at Bawdwin, and from its bright green colour cannot easily be mistaken. Usually it occurs in thin lamellæ along the shear-planes of the country rock with no well marked crystalline structure, but one small specimen

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1 Gazetteer of Upper Burma and the Shan States, Pt. 1, Vol. 2, p. 303.

which was picked up in the bed of the Nam-pang-yun stream exhibits a well marked botryoidal structure with a silky lustre on its fractured surface. No well developed crystals were collected, though the mineral was rarely seen in groups of very small acicular prisms. Malachite is invariably found in association with azurite.

**Azurite.**

Chessylite, basic cupric carbonate, $2CuCO_3 . Cu(OH)_2$. The blue copper carbonate occurs in the same way as the malachite with which it is always associated, *i.e.*, in thin films impregnating the country rock. Groups of small tabular crystals of azurite are not rare, the best specimens being obtained from the Upper Maitland workings where the mineral is found associated with malachite, anglesite and cerussite. Both malachite and azurite occur as coatings on anglesite at this place, and both carbonates are doubtless derived from the oxidation and alteration of chalcopyrite. Both copper carbonates have been found as thin coatings on pieces of rhyolitic rock, which was not however seen *in situ.*

**Calamine.**

Smithsonite of Dana, carbonate of zinc, $ZnCO_3$. Calamine (presumably the carbonate) has been recorded from Bawdwin by S. Henniker, Esq., A.R.S.M.[1] Amongst my own specimens from the same place, there is one in which anglesite crystals are coated with a thin bluish botryoidal mineral which I believe to be calamine, but the quantity is too small to permit of chemical determination.

## Notes on the Slags.

The Chinese, from the commencement of their operations in the 14th century until the year 1868 when they finally abandoned the mines, apparently worked and smelted the ores chiefly for the silver which they contained, allowing the greater part of the lead compounds and probably the whole of the zinc to run into slags. Great heaps of these extend at intervals for over two miles along both banks of the Nam-pang-yun. The location of the smelting furnaces appears to have been dependent on sites suitable for fuel and for water for dressing the ores, rather than on close proximity to the levels themselves.

1 *Mining Journal*, Jan. 16, 1906, p. 52.

It is unnecessary here to enter into the details of the metallurgical processes by which the ore was treated; this has already been done by Mr. LaTouche. Whatever may be said regarding the waste of lead and zinc by the ancient workers, it must be admitted that in the extraction of silver they attained very fair success. Granting that by the preliminary operations of washing and dressing the ores the Chinese were able to commence with a practically pure galena, and granting that the silver content of the Maitland ore be taken as a guide, then we may assume that they started with material carrying upwards of 80 ozs. of silver to the ton, whilst they finished with a slag containing roughly 1 to 2 ozs. to the ton. Of course modern methods of silver extraction would do better than this, but taking all things into consideration the Chinese methods though crude were essentially successful.

The slag or lead matte itself usually consists of heavy, dark-coloured, porous material sometimes of a vitreous aspect, but more often stony in appearance. It is largely intermixed with charcoal, doubtless the remains of the fuel by which the ores were reduced, and it is permeated by small shots or spherules of metallic lead.

Some of the more ancient heaps are now largely intermixed with débris and rubbish which has fallen from the hillsides, but it will not be a difficult matter to extract the valuable material. The slags as the following analyses show contain large quantities of lead and zinc, and small amounts of silver :—

*Partial analyses of slag from Bawdwin.*

| | Lead. | Zinc. | Silver. |
|---|---|---|---|
| 1 . | 47·8 per cent. | 16·7 per cent. | 2½ ozs. per ton. |
| 2 . | 49·33 „ | 18·20 „ | 1 oz. 15 dwts. 22 grs. and traces of gold per ton of lead. |

1 by Bewick, Moreing & Co. of London, based on 236 samples.
2 by T. R. Blyth (lead and silver) and J. Coggin Brown (zinc), based on eight samples.

Small amounts of copper, arsenic, iron, aluminium, manganese, calcium, silica and sulphur are also present, but not in quantities

large enough to make them of industrial importance. The small amounts of sulphur are noteworthy as they probably indicate a preliminary roasting of the sulphide ores. It is, however, not uncommon to find small lumps of undecomposed galena in the slag. The heaps are quite accessible and the amount of slag recoverable has been variously estimated at from 110,000 to 125,000 tons. Although, for want of time, I had no opportunity of personally verifying these estimates, yet judging from the number of trial pits which have been sunk the heaps have been very thoroughly prospected.

**Slag smelting.**

The smelting of ores of lead which are contaminated by zinc compounds is often a matter of considerable difficulty and is liable to be attended with a heavy loss of the metal sought for unless due precautions are taken. It is doubtful if any impurity can act more injuriously than zinc blende when present in large amounts. There are many processes by which such mixtures as the Bawdwin slags constitute may be successfully smelted, but it would be premature to enter into a discussion on their relative merits at present, for much depends on the location of the smelters with regard to a good fuel supply, and other details of a similar nature, and more still on the observed behaviour of the material when smelting experiments are performed upon it. The slags should certainly prove a valuable source of lead if their treatment be approached in a scientific manner.

**Some economic considerations.**

The Burma Mines Railway and Smelting Co., Ltd., who at present are the owners of the mining rights of the Bawdwin property, took over from the Great Eastern Mining Co., Ltd., their partially constructed railway to the mines, and are now engaged in carrying it forward.[1] On completion of the line, the Company propose to proceed with the smelting of the slags before undertaking the development of the mines.

From my examination of the slag I am convinced that the greater part of its metallic contents is recoverable, provided due regard be paid to its somewhat complex constitution in the choice of a proper method of treatment. It must not be forgotten, however, that the amount of available material is strictly

[1] Since the above notes were written, this line has been completed and smelters have been erected on Mandalay shore.

limited, and once operations are commenced the end, so to speak, is near. For this reason it is recommended that exploratory work in connection with the mines be commenced as soon as possible. It is impossible at this juncture to express any opinion as to the value of the ore-bodies which were not worked greatly by the Chinese, as their direction and extent is quite unknown.

There is little doubt that the Chinese workings were limited in depth by the level of the Nam-pang-yun stream, and that being possessed of no efficient drainage machinery the ancient miners were unable to work far below that level. It is reasonable to expect to find at no great depth valuable ores which could be easily won if a modern pumping installation were introduced.

As these questions, which are of such vital importance to the healthy development of a successful mining industry at Bawdwin, could be so easily settled by exploratory bore holes, one cannot urge too strongly the necessity for this kind of work. Mr. LaTouche, by a study of the geological structure of the district, has announced the most favourable part of the area for bore-hole sites, with a view to determine the position of the underground ore-bodies.

It is to be hoped that an attempt will be made to utilise the zinc ores which have been totally neglected in the past, but should at the present time prove of much value. Too little is known about the copper ores to enable any definite opinion to be given as to their value, but the Chinese are said to have worked two levels solely for the metal, and copper slags were found near the Kachin village of Loi Mi on the road from Nam Hsan to Bawdwin.

A picked specimen of sulphide ore from the Upper Maitland area assayed in the Geological Survey Office showed a large percentage of copper, and promises well for the value of the ore if it is found in larger quantities on further exploration.

I agree with Mr. LaTouche's remarks on the necessity for a thorough examination of the surrounding country, and on the preparation of accurate maps, without which it is impossible to prospect in a proper manner.

**Labour question.**

In the event of the development of a mining industry at Bawdwin, the question of the supply of labour is one which will demand serious attention. To recruit coolies from the inhabitants of the

country would certainly be the least expensive method of solving the problem, but it is to be feared that the Shans would prove practically useless for work of this kind. My own experience of these people agrees so well with that of Mr. R. R. Simpson of the Department of Mines that I cannot do better than quote his words[1]:—

"The Shans although a charming race socially, and physically fitted for labour, are contemptible as workmen. Owing to the fertility of the soil, they have abundance of food and raiment and comfortable houses wherein to dwell. Under these conditions they lead a contented life, and, perhaps wisely, fail to see the necessity for hard labour. The one thing they lack is ready money, and in order to supply this deficiency they will condescend to do a very moderate amount of work at double the rates of pay prevailing in India. To work on two consecutive days would appear to them to be mere foolishness, and besides this every fifth day they must attend the nearest bazaar in order to hear the news and enjoy a friendly pipe with acquaintances from neighbouring villages. Except for light tasks the Shans must be left out of count in the recruiting of a labour force."

The question, therefore, resolves itself into the use of Chinese or Indian labour, or a combination of both, for it is very doubtful if Burmese labour would be satisfactory, for the national traits of the Burman and Shan are very similar.

Considering the skill in mining with which the Yunnanese are endowed it would certainly be found best to employ them for this kind of work They are as a rule strong and very industrious men, somewhat undisciplined perhaps, but this fault could easily be overcome by good management. Indian labour could of course be imported, but it would be costly and certainly not so good as Chinese. There is also the racial difficulty to be taken into account, for during earlier exploratory work at the mines when Indians and Chinese were employed together, quarrels were frequent and free fights are said to have only been prevented by the exercise of great tact.

Taken, therefore, on the whole, it will be best to employ Yunnanese as much as possible, for on all points they have more to recommend them than any other available race.

**Transportation.**

By existing paths the mines are very inaccessible, and to get to them tedious journeys over mule-tracks of the usual kind found in mountainous frontier districts have to be made. A light railway, however, is now under construction, and when completed will

[1] *Rec., Geol. Surv. Ind.*, Vol. XXXIII, Pt. 2, p. 143.

connect the mines with the station of Manhpwi, which is a few miles above Hsipaw on the Shan State branch of the Burma Railways. This light railway will be some forty miles long, and will place the mines in direct communication with the port of Rangoon at a distance of some five hundred and ninety miles. Transportation by water along the Nam-Tu river from Hsipaw has been proposed, but there are difficulties in connection with this method which I believe are unsurmountable. The Nam-Tu river, like most of the streams of the Shan States, is frequently crossed by tufa bars and dams, which besides making navigation excessively dangerous, if not impossible, create rapids which no boat can cross. At places along its course the river flows in deep and narrow gorges which present another great obstacle to the use of boats.[1] For these reasons I consider that transportation of the ores or finished material by water is quite out of the question, although it would have been by far the cheapest method.

**General conclusions.**

The Bawdwin ores as far as can be gathered from material left by the ancient Chinese, consist of argentiferous galena with smaller quantities of zinc blende, iron pyrites, chalcopyrite, and various other minerals derived from these.

(2) The ore deposits at present visible do not occur in veins or lodes, but in bands of rock impregnated with minerals.

(3) Whilst the greater part of the area above water level has been exploited in the past by the Chinese, there is a good chance of meeting with payable ores at greater depths. Exploration for this purpose by means of borings is strongly advocated, together with the careful and systematic prospecting of the surrounding district.

(4) The slags left by the Chinese workers are rich in lead and also contain a good deal of zinc. There appears to be no reason why they should not constitute a valuable source of these metals, if their treatment be approached in a scientific way.

(5) In case of mining developments at Bawdwin, the question of a labour supply will have to be faced. Considering the natural aptitude for mining which the Yunnanese display, combined with their industry and endurance, it is concluded that it will be best to employ them in preference to Indians, Burmese or Shans.

[1] Mr. LaTouche, who has travelled along the greater part of the Nam Tu valley in the Shan States, informs me that below Tong Ang ferry south of Hsipaw the gorge is *absolutely* impassable by boats.

## EXPLANATION OF PLATES.

Plate 12.—General view of Bawdwin, showing character of scenery, and slag heaps in foreground.

„ 13.—The Amphitheatre, Bawdwin, an ancient quarry-working enlarged by landslips.

„ 14.—Chinese smelting furnace, showing hearth and arrangement of flues.

„ 15.—Details of Chinese smelting furnaces, scale 1 inch = 4 feet.

*a.* Front elevation. *b.* Plan. *c.* Longitudinal section.

„ 16.—Kachin smelting furnaces and remains of Chinese huts.

„ 17.—Details of Kachin smelting furnace, scale 1 inch = 2 feet.

*a.* Front elevation. *b.* Plan. *c.* Section.

„ 18.—Ore dressing floors.

„ 19.—Chinese cupel furnace, and ore crushing mortar.

„ 20.—Details of cupel furnaces.

Fig. 1. Square cupel furnaces, scale 1 inch = 4 feet.

*a.* Front elevation. *b.* Plan of top. *c.* Section.

Fig. 2. Round cupel furnaces, scale 1 inch = 2 feet.

*a.* Front elevation. *b.* Plan of top. *c.* Section.

„ 21.—Miscrophotographs of Bawdwin rocks.

Fig. 1. Rhyolite exhibiting flow structure.

„ 2. Bawdwin grit; minerals almost entirely replaced by galena.

„ 22.—Microphotographs of Bawdwin rocks.

Fig 1. Tuff: minerals partly replaced by galena.

„ 2. Tuff: commencement of the replacement of the groundmass by galena.

, 23.—Sketch-map of the Bawdwin District, scale 1 inch = 2 miles.

„ 24.—Horizontal sections.

Fig. 1. Section across the Nam Tu valley near Lilu, scale 1 inch = 1 mile.

Fig. 2. Section through Bawdwin, scale 1 inch = 1 mile.

# RECENT ACCOUNTS OF THE MUD VOLCANOES OF THE ARAKAN COAST, BURMA. BY J. COGGIN BROWN, B.Sc., F.G.S., F.C.S., *Assistant Superintendent, Geological Survey of India.* (With Plate 25.)

## INTRODUCTION.

THE mud volcanoes which are grouped on and around Ramri and Cheduba islands[1] off the Arakan coast were first systematically studied by Mallet, whose report is to be found in *Rec., Geol. Surv. Ind.*, Vol. XI, Pt. 2, pp. 188—207.

A comprehensive summary of this account has been given by Oldham, in the *Manual of the Geology of India*, second edition, pp. 20—22, from which the following short description is taken :—

"There are about a dozen or rather more vents in Ramri island itself, more than half that number in Cheduba and a few in other neighbouring islands. Many of the vents consist of truncated cones, built up of the dried mud ejected by the outbursts of gas. The crater, filled with more or less liquid or viscid mud through which the gas escapes, occupies the top of the conical hillock. The majority, however, of the Ramri mud volcanoes consist of mounds, composed on the surface of angular fragments of rock and having scattered over them a few small mud cones with craters at the top, varying in height from a few inches to eight or ten feet. When gas ceases to be emitted from a vent, the mud is rapidly washed away by the rain and there remains a low mound, composed of angular fragments of rock which were ejected together with the mud, and the repetition of a similar process accounts for the formation of the mounds.

"The mounds in Ramri are from 50 to 100 yards in diameter, with a height of from 15 to 20 feet: two, of exceptional size, near Pagoda Hill in Cheduba, being 200 to 250 yards across. The cones in which the mud is viscid are very steep, being built up partly of small quantities of mud, spurted out by the evolution of gas so as to form a hard rim round the mud crater, partly of mud poured out from the crater down the slopes through broken portions of the rim. Besides the gas and mud, a small quantity of petroleum is usually discharged from the vents. The gas consists mainly of marsh gas, probably mixed with some of the more volatile

[1] Ramri and Cheduba islands, with a small archipelago of lesser islets stretching to the north and south along the coast, are separated from the mainland by a number of tidal creeks and form part of the Kyaupyu district,—a seaboard district which is situated in the centre of the Arakan Division, Lower Burma, lying between 18° 40′ and 20° 41′ north latitude, and 93° 13′ and 94° 26′ east longitude.

hydrocarbons usually associated with petroleum. The mud is simply the grey shale or clay of the tertiary rocks, mixed with water containing some salt in solution."

Although under ordinary circumstances it is usual for the mud to be slowly ejected from the craters accompanied by saline waters and bubbles of gaseous hydrocarbons, yet occasionally the Arakan mud volcanoes are subject to paroxysmal outbursts of extreme violence. At such times mud and stones are thrown out with great force and noise, immense quantities of inflammable gases are liberated, which, becoming ignited, light up the country for miles around, and are visible far out to sea. If the eruption happens to be submarine, the ejections of stone and mud sometimes form islands, which are, however, soon removed by the action of the waves.

From time to time accounts of violent eruptions of this nature have reached the Geological Survey Department, and in 1885 Mallet published a list of those that had been recorded up to that date (*Rec., Geol. Surv. Ind.*, Vol. XVIII, Pt. 2, p. 125). A later eruption of the Cheduba mud volcano took place at 11 P.M., 3rd July 1886, and is mentioned in *Rec., Geol. Surv. Ind.*, Vol. XIX, p. 268. From that time until October 1893 there are no records of any other eruptions of the mud volcanoes of this group.[1]

*List of recorded eruptions which have taken place since October 1893.*

| Locality of volcano. | Date of eruption. | Character of eruption. |
|---|---|---|
| Cheduba | 19th July 1903 | Violent. |
| Cheduba | 21st January 1904 | Very violent. |
| Research Strait (submarine) | February or March 1904 | Shoals formed. |
| Beacon Island (submarine) | 15th December 1906 | Very violent, new island formed. |
| Unguan Island (submarine) | 20th April 1908 | Violent. |

[1] *Mud volcano in Tipperah.*—In March 1897 a small active mud volcano was discovered in cultivated land at the foot of the Tipperah hills, on the eastern boundary of Tipperah district, and 16 miles due north of the sadar station of Comilla. The site of the little eruption is in a village called Ballabpur, and is said to be in 91° 15′ 30″ east longitude and 23° 40′ 30″ north latitude. Although not connected with the Arakan mud volcanoes this occurrence in Hill Tipperah is near enough to them to make it worth recording here. *Rec., Geol. Surv. Ind.*, Vol. XXX, Pt. 2, p. 111.

The remarkable absence of information between 1886 and 1903 is probably partially due to the fact that the mud volcanoes have been passing through a period of quiescence and also to the lack of evidence of eruptions which may have taken place. Mallet has stated that there is no reason to suppose that eruptions were less frequent between 1846 and 1878 than before or after these dates, the gap in the list of recorded eruptions then being doubtless due to imperfections of the record (*Rec., Geol. Surv. Ind.*, Vol. XVIII, p. 124). Following the practice formerly pursued, it is proposed to give here extracts from the reports of eye-witnesses, who were fortunate enough to see the eruptions.

## Eruption of the Cheduba Mud Volcano in October, 1893.

There are no details available regarding the eruption of the Cheduba mud volcano which is said to have taken place in October, 1893. The eruption is only casually mentioned in an account of the one which took place on the 21st January, 1904.

## Eruption of the Cheduba Mud Volcano on the 19th July, 1903.

The official report of the Commissioner of the Arakan Division to the Revenue Secretary of the Government of Burma runs as follows :—

"I have the honour to report an eruption of the volcano in the Cheduba island, Kyaukpyu district, on the 19th July, 1903. The information reached me from a private source. No Government official seems to have considered the matter of sufficient importance to send in a report, if any saw it. Mr. Dunlop, who is a resident on the island, says that it was the most magnificent sight he ever saw. At 11 minutes to 1 P.M. he saw a black cloud shoot up from the earth (no doubt mud) and in a moment flames burst forth and shot skyward, 500 to 1,000 feet high, accompanied with dense clouds of black smoke. The flames lasted just 17½ minutes, which is said to be the longest ever remembered. No eruption of the volcano has taken place for the past 10 years and it is thought that is the reason why it was so violent. It is said that formerly there used to be a slight eruption once a year."

## Eruption of the Cheduba Volcano on the 21st January, 1904.

The eruption of the Cheduba volcano which took place on the 21st of January, 1904, is said by eye-witnesses to have been the longest and most violent ever known. A report of the occurrence

by Mr. R. S. Dunlop, opium licensee of Cheduba, was forwarded to the Government of Burma by the Commissioner of the Arakan Division, and is partially reproduced below:—

"On Thursday, the 21st instant, the mud and fire volcano on this island had another fire eruption, which started about 2 P.M., and lasted for about 45 minutes. In all respects it was more violent, and lasted much longer than the eruption of July last, or any former eruption, although accompanied with less smoke.

"It may be remembered I stated in my report, dated July last, that no fire eruption had occurred for 10 years, *viz.*, October, 1893. It was presumed for causes stated in that report that fire eruptions had ceased, and people were surprised at the eruption in July, but much more so at the present one. Usually, former eruptions were 10 to 12 months after each other and sometimes a little longer, but now this one coming just six months and two days after the last makes one wonder what's coming next. I left Cheduba on Saturday evening, the 23rd, to see for myself what it looked like. We halted all night near the volcano, getting there early next morning.

"I was here 17 years ago; the place generally looks pretty much the same as it did then, the small mud volcanoes being built up higher and higher every day as the mud is thrown up and dries. Some of them are now quite 20 feet high and getting higher every day, one of them in particular is very pretty, being shaped just like a pagoda, and might at a distance be taken for a small one, it being quite white. The large volcano has, however, undergone quite a change, the mud instead of being semi-fluid as it was 17 years ago, is now of the consistency of very thick porridge, and instead of nearly white as then, is now nearly black. The mud which has been thrown up covers a considerable area and to quite a height: however, during the rains this piled up mud is washed away, leaving the place nearly level. The washings cover a large area, and wherever they go all vegetation is destroyed, outside this area there is a scanty growth of stunted wiry grass. The volcano is situated on a gentle incline sloping towards the south, consequently most of the washings go that way, so that what vegetation there is, is closer to the volcano on the north than on the south.

"We came from the north, and the first things I noticed were two large fissures or crevices extending outwards from the volcano into the grass for over 200 yards, and about 50 feet apart, running in a zig-zag direction from S. E. to N. W. One could see from their size that they had started in the mud lately thrown up, as the further out, the smaller they became till the end. Near the mud, one of them was V-shaped, about six feet across the top and nearly as deep, the other one was not so long. They must have been much larger just after the eruption, but now appear to be closing up.

"The mud at the bottom is quite soft and I could run the whole length of my walking stick down into it quite easily. No doubt the fissures were caused by the late eruption as the earth where thrown up was

quite fresh, evidently they were first of all opened by escaping gas and then partially closed. What depth they were at the time of the eruption no one can tell. Some distance to the north of this is a large mound said to have been the former crater, but I doubt this though it might have been a smaller volcano which has now become extinct. Mud is piled up in an irregular circular form like a huge embankment about 400 yards across and at least 8 feet high. I am informed that all this mud was thrown up by this eruption, as formerly the ground was quite level. If this is so, and I have no reason to doubt it, what a gigantic force must have been exerted to throw up these thousands of tons of mud in the space of a few minutes. When I last visited the place, I had no trouble at all in locating the crater. It was filled with hot fluid mud, boiling and bubbling like a huge pot, but I could find no such crater this time.

"I walked all round the huge embankment (of mud), and then straight across the centre, and then again at right angles to my former course, but I could find no signs of a crater, nothing but gaping fissures all over the place. All over this area, the mud in the fissures was much softer than in the two fissures mentioned above; no doubt deeper down still fluid mud may be found. My impression is that the mud is gradually becoming hard. I noticed in the small volcanoes that it is much thicker than it was 17 years ago. I could find no trace of fire anywhere.

"One would have thought that so large a fire would have kept its mark somewhere, but this may be accounted for by the northerly wind which was blowing at the time, the vegetation to the south being quite a distance from where the fire occurred. Perhaps fresh mud may have been thrown up after the fire had died down and so obliterated all marks around the volcano itself. It is fortunate that no lives were lost, as the main road is close by and the eruption was quite unexpected."

Mr. Dunlop then refers to the legend in vogue amongst the Arakanese, that a spirit—the *Naga*—is responsible for the eruptions from the volcano. He also relates how 30 years ago, the natives say, a violent eruption took place in which five persons perished, the outburst being due to some one mockingly asking the *Naga* for fire to light his cheroot. The insulted *Naga* granted the request with the above tragical result!

Mallet relates a very similar legend and is inclined to believe that such stories have their foundation in the fact that flames sometimes suddenly issue from the volcanoes. He is, however, sceptical as to the fatal results which are said to accompany them (*Rec., Geol. Surv. Ind.*, Vol. XI, Pt. 2, p. 200).

## Eruption of a submarine Mud Volcano in the middle of Research Strait in February or March, 1904.

A report on this eruption was forwarded to the Geological Survey Department by the officer in charge of the Marine Survey

of India, and is dated 1st March, 1904. This report is partially reproduced here:—

"During the progress of the survey of the Arakan coast, a small mud volcano has been discovered in the middle of Research Strait due east of the southern end of Western Baronga.[1] It consists of three vents forming an equilateral triangle with sides about 50 yards long, apex north, the vent at the apex was the only one discharging mud, and it emits gas and mud at intervals of from 15 to 60 seconds like a geyser in a true volcanic district. The two southern vents emit gas in a constant flow, but no mud.

"The volcano has formed a shoal about 200 yards in extent, on which the depth is from seven to eight fathoms, except at the spot the mud is at present discharged from, where a sudden shoaling to 3¼ fathoms takes place. The depths around the shoal are 15 fathoms. A self-recording maximum and minimum thermometer, when lowered to the bottom at the spot the gas and mud were being discharged from, showed no variation in temperature from that of the water around the shoal. A small quantity of gas was obtained and found to be highly inflammable, colourless, *odourless*, tasteless, and neutral to litmus paper tests; from this it is inferred that the discharge is marsh gas similar to that found in the Ramri and Cheduba islands. A specimen of the bottom was obtained and found to consist of gray mud mixed with angular fragments of rock of the same colour."

## Eruption of a submarine Mud Volcano off Beacon Island on 15th December, 1906.

The eruption of this submarine volcano is one of the severest on record, for a new island which appears to have been much larger than those previously formed, was piled up in the Bay of Bengal. The new island was situated in lat. 19° 0′ 6″ N., and long. 93° 24′ 20″ E., and 8¾ miles in a north-west by north direction from the north-westernmost point of Cheduba island. Beacon Island lies south-east by south about 4½ miles from the new island. Fortunately the phenomena associated with the building up of the island were witnessed by a competent observer, Mr. S. Dawson, Inspector of Lighthouses, Rangoon, who happened to be on Beacon Island at the time. His observations are given below:—

"About 7 A.M. in the morning of the 15th December, 1906, being on Beacon Island, I saw what appeared to be an island towards the north-

[1] Western Baronga Island is the outermost of a group of three islands, which lie a short distance from the coast, near the mouth of the Kaladan river in the Akyab district, Arakan Division of Lower Burma.

west, at an approximate distance of 10—15 miles, but misty and indistinct. I pointed it out to my serang, who agreed that it was land, but I knew that no land existed west of a line from Beacon to Kyaukpyu. All the men had noticed it. While talking about it to my serang, some Burman fishermen, who had come to the island in the afternoon of the 14th, came and told me that their canoe had been washed away in the night and that they had no food in consequence.

"This circumstance afforded some evidence as to what had occurred. It is to be noted that spring tides, having started about the 12th, were very high on the 14th and 15th. But the high tides occurred in the evening of the 14th at about 6 P.M. and on the 15th in the morning. I then remembered that I had been wakened in the night by what I thought at first was the noise of the wind rising, so I rose up and looked out. There was not much wind but a very heavy surf was booming on the beach, I then struck a match, looked at my watch and found the time was 12-45 midnight, and the tide must then be dead low.

"Naturally at that hour of the night I did not think of volcanic upheavals or consequent tidal waves, so, attributing the heavy seas rolling in to the turn of the tides, I went back to bed. Recalling this incident when the Burmans told me that their boat had gone in the night, I concluded that it must have been taken away by one of the enormous waves which rolled in at midnight. The Burmans, on landing the previous day, were aware of the high tides and drew their boat up well above high water mark. This I remember observing in the afternoon. From the facts given above it is to be deduced that the upheaval resulting in the formation of the island now existing above water took place at about 12 midnight of the night of the 14th and the waves which took away the boat must have been at least 14 feet high. I continued to watch this island, being still in doubt as to the true meaning of the phenomenon, but about 9 A.M. I noted black smoke in two jets like that of a steamer in the distance and these gradually turned to white steam issuing in one enormous 'cumulus' the whole length of, and above, the new island.

"As the sun became hotter, about 11 o'clock A.M., a fairly heavy bank of cumulus clouds formed and lay most of the day over the island, there being practically no wind. At this time I proceeded to send my men out to jump holes in the rock lying off the jetty for blasting, but though as I say there was no wind all the morning, nevertheless they were washed off the rock by the high swell rolling in from the direction of the eruption and were unable to work in consequence. The sea, too, which since I landed on the 6th instant had been clear and sparkling, had now become muddy and dull. While recalling my men from their efforts to work on the rock, as I stood on the end of the jetty I observed huge volumes of mud and water spouting up into the air to a height of what must have been hundreds of feet. These ejections were black and they continued intermittently for some 10 minutes. This was at a distance of some four times the apparent width of the island to its right from my observing point; and I should say considerably nearer to me. No shock or tremor was reported at any time by any of the men. All day spouts or columns

of water and steam were observed thrown up all round the island, but towards the afternoon the steam cloud from the island itself disappeared. I continued to keep a sharp watch on the island all day and I noted that the atmosphere was very clear, yet very dull-clear, because the coast showed up much more distinctly than usual, and yet dull, because the sun scarcely cast a shadow even at noon.

"At 4-30 P.M. I went to the summit rock here to observe the sunset. As I sat, I should remark that I felt it very cold though there was scarcely any breeze: at this time, too, I remembered that I had noted the day before about sunset how cold it was compared with other evenings, and I naturally attributed this sudden change in temperature to atmospheric conditions resulting from the volcanic phenomena around. On taking a rough bearing of the island I found it to be about 36° west of north from Beacon, and distance 12 miles. After dark I could observe no light nor sign of any electrical disturbance over the island on the 16th. Spouting and eruptions smaller and of less frequency than the day before continued around the new island. I kept a watch of men all night, but they had nothing to report.

"On the 18th, having procured a boat, I rowed off to the new island, and found the distance to be not more than 6 miles. My first guess therefore as to its distance from Beacon Island must have been in error, due to the vapour in the atmosphere. On approaching within a quarter of a mile or less, I rowed all round it looking for a possible landing place as the swells were breaking heavily.

"The sea was very muddy, and all around the boat small ebullitions of steam and sulphurous vapours bubbled up; and when I got to the north-west side I noted many small geysers spouting steam and mud to a height of about 15 or 20 feet on the island itself. Having found a likely landing place, I backed my boat in as near as was safe just outside the breakers, and taking a line, swam ashore. I had great difficulty in walking the first hundred yards of beach, as I sank deep in the soft mud and the heat of it was just bearable. The sea as I swam was noticeably warmer than at Beacon Island, as might be expected. On arriving above high water mark the mud became firmer having dried a little in the two days which had elapsed. Higher up it was cracked and resembled a field which had been ploughed and harrowed. I went on up to the top—a height at that time of about 40 feet or more—and from this point I could see the whole of the island. One could notice the form of the main crater which was roughly a plateau formed by a dried-up lake of mud with concentric corrugations of mud, resulting from the intermittent paroxysms, extending down the sides of it.

"From the still active geysers a most objectionably smelling gas was given off. I was watching these for perhaps an hour when the ground I stood on and in fact the whole island started to sway about; so taking this as a possible preliminary to another paroxysm I hurried back as quickly as I could to the boat, and came away, having procured a bucketful of the liquid from one of the geysers, which I thought might be called for, for analysis. On January 3rd the station ship *Dalhousie* called at the

island with me on board and I observed a great difference in its height. It must have subsided about 20 feet since I first saw it."

Commander W. B. Huddleston, R.I.M., Port Officer of Akyab, visited the island on the 22nd or 23rd of December. On December 30th the R.I.M.S. *Investigator* under the command of Commander W. G. Beauchamp, Royal Indian Marine Surveyor in charge, Marine Survey of India, proceeded to the island to fix its position. The reports of Commander Beauchamp and of Captain R. E. Lloyd, I.M.S., Surgeon Naturalist to the Marine Survey of India, are reproduced here. It should be mentioned that accounts of this new island have appeared both in the daily press of India and Burma and also in several scientific publications.[1]

## Extract from Commander Beauchamp's report.

"I am informed by Commander Huddleston, the Port Officer of Akyab, that the island was formed on the 15th December. Commander Huddleston landed on the island on the 22nd or 23rd of December, and on his return gave me practically all the information he had obtained. I arrived off Volcano Island on the evening of the 30th, having spent Christmas at Akyab where I coaled and watered, took magnetic observations and rated chronometers.

"Volcano Island observation spot, which is marked with a Marine Survey socket and pole, is situated in lat. 19° 00′ 06″ N., long. 93° 24′ 20″ E., depending on Madras Observatory being in long. 80° 14′ 51″ E., *vide* Admiralty Chart of Cheduba Strait and Ramri Harbour, No. 832. The island has a greatest length of 307 yards in a south-south-west and north-north-east direction and a greatest breadth of 217 yards in a north-west and south-east direction, and the summit is 19 feet above high water.

"The ship anchored at a distance of $\frac{3}{5}$ mile to the south-east of the island in a depth of about 11 fathoms at low water, corresponding with what is shown on the chart. Soundings were taken in all directions of something over a mile. Except close into the shore, the soundings are practically the same as shown on Admiralty Chart No. 832, including the shoal to the north-north-west which was also touched. The ship approached the island from the north-east and left in an east-south-east direction. A steam-boat left to the southward for 10 miles and returned from the south-south-east, and on neither course was any discrepancy in the chart discovered.

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1 "A New Island in the Bay of Bengal," by Lieutenant E. J. Headlam, Royal Indian Marine Survey of India. *The Geographical Journal*, Vol. XXIX, No. 4, pp. 430—436. Plans, sketches and photographs appear with this article.

"A New Volcanic Island," by Admiral A. Mostyn-Field, Hydrographic Department, Admiralty, London. *Nature*, February 28th, 1907, p. 414.

"A New Mud-Volcano Island," by F. R. Mallet. *Nature*, March 14th, 1907.

"The island is still in an active condition at the northern end, several hot springs of liquid mud overflowing. It is steeper on the western side. The soundings off the island itself point to the fact that it is an isolated pinnacle or crater. Temperatures (Fahrenheit) were taken at different parts of the island. The surface registering 81°; two feet below the surface 96°; three feet below the surface 104°. But at the observation spot on the summit, and evidently the main crater, the temperature at one foot below the surface was 104°; at two feet below 108°; at three feet below 138°; and at three and a half feet the thermometer rose to 148°. I had no self-registering thermometer to take the temperature of the liquid mud. The ordinary thermometer could not be cleaned quickly enough to get an accurate reading. The island is evidently becoming hard, but the action of the sea and tide is washing it away considerably at present, leaving a wake of discoloured water where the tide takes it off, giving it the appearance of a shoal. At present, however, there still appears to be nearly as much mud deposit from below as is carried off by the sea. The south-west monsoon is likely to have some effect on the island. It will be noticed from the Admiralty charts of this neighbourhood that there is apparently a volcanic ridge from Cheduba Island to Baronga Island near Akyab, trending north-north-west and south-south-east. Drift wood, sand and stones were found on the island; fourteen kinds of seeds were collected by the Surgeon Naturalist, whose geological report I have called for and enclose with this."

## Report of Captain R. E. Lloyd, Indian Medical Service, Surgeon-Naturalist to the Marine Survey of India.

"The island is composed wholly of greyish brown mud, of uniform quality throughout; with this are a few angular fragments of rocks of various kinds intermingled. These must have been thrown up by the mud and include—

(*a*) portions of a laminated sandstone;
(*b*) a compact grey rock which has the appearance of limestone but which is only partially soluble in strong acids;
(*c*) lumps of crystalline calcite;
(*d*) a soft green stone, probably a basic igneous rock.

"On December 31st the surface was sun-dried and hardened so as to readily support the weight of a man. The dried surface is very uneven throughout, it has a nodular and bubbly appearance, besides this it is split up by deep fissures due to shrinkage in drying. On the north side of the island are several small vents. Three of these open into round pools of liquid mud, to the surface of which large bubbles of gas are continually rising.

"The gas is non-inflammable, and does not support combustion. It has an objectional, sulphurous smell. Although the island has probably been in existence only 16 days, already large quantities of drift wood have collected on the shore. Among this were found 14 varieties of seeds and

fruits of shore-frequenting plants, many of which are capable of germination. In regard to the permanence of this island, considering the nature of the material of which it is composed, it is likely that heavy rains and sea action, in the south-west monsoon, will cause rapid disintegration and total disappearance, always provided that no more material is erupted. The rocks and seeds collected will be forwarded to the Directors of the Geological and Botanical Surveys of India, respectively."

The specimens referred to by Captain Lloyd were forwarded to the office of the Geological Survey Department and were specially examined by Mr. E. H. Pascoe, Assistant Superintendent, Geological Survey of India, who has had considerable experience of the Tertiary beds of Burma. Mr. Pascoe reports as follows on the specimens:—

"(*a*) Might easily be a variety of the calcareous laminated sandstones found in the Pegu beds and sometimes in the Irrawadi sandstone beds. I have not come across its exact equivalent in colour.

(*b*) A blue mudstone common in the Pegu beds.

(*c*) I have not come across calcite in such thick veins, but similar veins occur in the Pegu or Irrawadi sandstone beds.

(*d*) I have not seen many *green* clays, but those resembled more or less this type, and occurred in Pegu or Irrawadi sandstone beds.

(*e*) A dark fine-grained mudstone similar to those in the Pegu beds.

(*f*) Certainly organic. No coral structure visible, more probably some form of Serpula.

"It would be impossible to say with any certainty what the age of the beds is, but if one might hazard a guess, it would be Pegu series."

In his account of Volcano Island, as the new island was named, Lieutenant Headlam[1] states:—

"The island, on approaching from the eastward, presented a long low appearance of a uniform greyish-brown colour, having a small knob or summit on its southern end; no smoke or sign of activity was noticed; from a distance of half a mile the water shoaled gradually to the beach. On landing we found the upper crust quite hard and cool, except quite close to the beach, where the mud was soft—so soft in places that we sank above our knees. The whole island was, with the exception of a small quantity of stones and sand, entirely composed of greyish-brown mud of a clayey nature, with an extraordinarily rough surface, caused by the quickness with which the boiling mud had cooled with exposure and the cessation of the eruption. The island is a rough diamond in shape, with the highest part at its southern end, and extending in a ridge formation in a north-north-easterly direction, with small gullies and ridges branching off on either side. The main ridge is about 16 feet above high water (with the exception of the knob at the southern end), and is about 40 yards

[1] *Geographical Journal*, loc. cit., p. 431.

broad; the land then slopes down to the sea, being slightly steeper on the western side.

"There was no activity visible except at the northern end, where several small craters, varying in size from 1 to 6 feet in diameter, were exuding liquid mud, but only in small quantities and not with any great violence. I computed that the whole output during the day I spent there would not exceed two tons. The whole island gave out a strong smell of sulphur, which was almost overpowering close to the holes bored for taking the temperatures.

"A study of this part of the Burma coast seems to show that this island is part of a chain of mud volcanoes which appear along the eastern side of Cheduba island and the islands immediately to the southward, some of which are several hundred feet in height and are occasionally active; and again continuing the line for some 50 miles further to the northward, we came to another mud volcano (active, but still some feet below the surface of the sea), which is situated just inside the southern point of the Eastern Baronga, about 20 miles to the south of Akyab, and which was discovered by the officers of the R. I. M. S. *Investigator* whilst surveying there four years ago.

"A beacon and flag were erected on the island as a mark to help in fixing the position, and also to draw the attention of passing ships to this uncharted danger, which, on account of its lowness and drab colour, is very difficult to see until fairly close, more especially in misty weather."

## Eruption of a submarine Mud Volcano near Unguan Island, Arakan Coast, on the 20th April, 1908.

There are no detailed accounts on record of this, the latest of the recorded eruptions of the mud volcanoes of the Arakan coast. The only information available is a copy of a telegram from Marine Surveyor, Kyaukpyu, to the Government of Burma, a copy of which has been forwarded to the Geological Survey Department by the Government of India.

"Following telegram, dated 6th May, received from Marine Surveyor, Kyaukpyu:—Discovered small mud volcanic island violently active in southern extremity Nerbudda shoal bearing from centre Unguan Island south 19 east, distant 5¾ miles. Approximate position 18° 21′ north, 93° 56′ east. Eruption observed from mainland on night of 20th ultimo."

## Other Indian Mud Volcanoes.

The mud volcanoes of the Indian Empire can be arranged in four geographical groups situated respectively along the eastern and western borders of the Arakan Yomas, in the Gomal valley along the Afghanistan-Baluchistan frontier, and along the Mekran coast.

The group situated on the eastern border of the Arakan Yoma was first examined by Dr. T. Oldham,[1] and has since been described in great detail by Noetling.[2]

The popular idea that these mud volcanoes are associated in some way with true volcanic action, as it is usually understood, is entirely erroneous as was shown by Mallet. They must be regarded as extrusions of mud brought about by pressure of the lighter petroleum hydrocarbons along some line of weakness in the strata. The accumulation of gases and oil along the anticlinal arches of the miocene strata on both sides of the Arakan Yoma is a fact so well known as hardly to need repetition. Owing to faulting or accidental fissuring the pressure is relieved and the gases breaking through the remaining superimposed strata form a mud volcano. In other anticlinals the pressure is either not strong enough to force gas, water and oil through the shale and clay bands, or else the pressure has been gradually relieved through the existing fissures.

The petroleum mud-volcanoes of India and Burma can be compared with those which occur in the Appenines at Sassuolo and other places, with those occurring at the eastern and western end of the Caucasus in the neighbourhood of Baku and Taman, respectively, with those of the Bezeu district in Roumania and in many other parts of the world. Suess[3] has indeed called attention to the remarkable combination of geological characters which the Arakan Yomas exhibit in company with certain parts of the Carpathians, the Caucasus and the Appenines.

These petroleum mud-volcanoes are essentially different to the occurrences in the Yellowstone district of America, in New Zealand, in Iceland and elsewhere, which are unfortunately called by the same name. The latter owe their origin and activity to the high temperature of the layers of the earth's crust close to the surface, and to the action of steam which is consequently produced when meteoric waters find their way into the ground.

1 "Notes on the geological features of the banks of the Irrawadi, and of the country north of Amarapoora," by T. Oldham in "*Mission to the Court of Ava,*" by Captain Henry Yule. London, 1858. Appendix, p. 341.

2 "The occurrence of Petroleum in Burma," by Dr. Fritz Noetling. *Mem., Geol. Surv. Ind.*, Vol. XXVII, pp. 35—49.

3 "The Face of the Earth." Suess, English Translation, Vol. I, p. 454.

## Formation of new Islands.

There is nothing unique in the formation of the new island so aptly described by Mr. Dawson and the officers of the Royal Indian Marine Service. The eruptions of January 26th, 1843, and March 12th, 1874, are said to have been characterised by the same island-like formation. The latest chronicled eruption of April 20th, 1908, must also come into the same class. If the eruption happens to take place under the sea,—and it should be borne in mind that the sea off the Arakan coast of Burma is more than usually shallow,—a new island will be formed, provided that the ejected mud is viscous enough to withstand the action of the waves, currents and tides for any length of time, and that the eruption is violent enough to eject sufficient material to reach the surface of the sea. The submarine eruption which took place near the Baronga Islands in February or March, 1904, only resulted in the production of a shoal, either, because of the feeble character of the outburst, or, because of the strong scouring action of the currents and tides in that particular region, so that the ejectementa were washed away before they had time to accumulate to a height sufficient to be raised above the surface of the sea.

The island which was formed on January 15th, 1843, is said to have been quickly washed away and the new island which appeared above the surface of the sea on December 15th, 1906, has now shared the same fate.

The most recent information concerning this island is embodied in the following telegram from Commander W. G. Beauchamp, R.I.M., dated the 24th December, 1908:—

> "Volcanic Island off Beacon Island examined by me 27th February last when it had become submerged to the depth of 14 feet over an area of one mile, but was in an active state."

The presence of such an abundance of drift-wood and different kinds of seeds on the island so soon after its formation is very interesting, and helps to a realisation of how short a time it would take for the mud to become covered with vegetation. This would have a tendency to make the island a permanent feature of the coast, provided other and more potent agencies were not at work to accomplish its destruction.

The formation of new islands has been observed in the Caspian Sea in connection with eruptions of the mud volcanoes of the Baku district.[1]

## Connection between paroxysmal outbursts and earthquakes.

Mallet, writing in 1878, considered that there was an intimate connection between the Ramri mud volcanoes and seismic disturbances. He said [2] :—

"During the principal shock of the violent earthquake on the 26th June, 1833, it is stated by Dr. McClelland that flames issued to a height of several hundred feet from one of the Kyouk Phyu salses.

"A similar occurrence took place during the earthquake of the 23rd March, 1839. The submarine outburst near False Island of the 26th July, 1843, was immediately preceded by a like disturbance. Further, during the great earthquake of 2nd April, 1762, two volcanoes are said to have opened in the Chittagong district. If these really were mud volcanoes, and there seems no reason to question it, they were doubtless of the same class as those in Ramri."

It is perhaps more than a coincidence that the outburst of the mud volcano which resulted in the formation of the new island near Beacon Island on 15th December, 1906, occurred only a few days after the Calcutta earthquake of 6th December. 1906.[3] As Mr. Middlemiss has pointed out, the Gangetic delta "itself, or the sub-structure of hard strata underlying it, is still capable of generating occasional earthquakes" and cannot be regarded as having attained a permanent degree of stability or immunity from shocks. There is no reason to suppose that a severer shock than usual would not affect in some measure the neighbouring districts of the Arakan coast. Unfortunately the list of recorded eruptions is not great enough to allow of any information being obtained as to the behaviour of the volcanoes during the great Indian earthquakes which have taken place in recent years. However incomplete the record may be, there is something in the theory that the paroxysmal outbursts of the Arakan mud vol-

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[1] Kayser. "Lehrbuch der allgemeinen Geologie," Vol. I, p. 489.
Abich. "Uber eine im Caspischen Meere erschienene Insel." *Memoirs de Acad. Imp. de St. Petersbourg*, Ser. VII, VI.

[2] *Rec., Geol. Surv. Ind.*, Vol. XI, Pt. 2, pp. 206—207.

[3] *Rec., Geol. Surv. Ind.*, Vol. XXXVI, Pt., 3, pp. 214—232.
C. S. Middlemiss: "Two Calcutta Earthquakes of 1906."

canoes are apparently sympathetic responses to seismic disturbances in their neighbourhood. The linear arrangement of the Indian mud volcanoes is by no means an uncommon occurrence, like the nearly straight line of salses which run across Sicily and to the similar arrangement of the Baku mud volcanoes

This seems to add confirmation to the theory, for the mud volcanoes are doubtless aligned upon fissures or some other line of weakness in the strata. It may be supposed that the effect of a sudden shock on such an unstable system might be either to loosen the superimposed strata and allow the pent-up gases to escape; or to close up the fissure from which they were gradually escaping, and so allow of sufficient pressure being developed as finally to rupture the strata with explosive violence and shoot out immense volumes of mud, water, oil and gases, into the air or sea as the case might be. Mallet believed that the ignition of the gas was due entirely to frictional electricity and the consequent production of sparks.

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# GYPSUM DEPOSITS IN THE HAMIRPUR DISTRICT, UNITED PROVINCES, BY T. D. LATOUCHE, B.A., F.G.S., *Superintendent, Geological Survey of India.*

IN the month of August, 1908, information was received from the Collector of Hamirpur District in the United Provinces, and from the Political Agent in Bundelkhand, that deposits of gypsum had been discovered at several places situated on the alluvial plain in the angle between the Bairma river, a tributary of the Betwa, and the latter river, about half way between Hamirpur town and Kulpahar, on the Jhansi-Manikpur Railway. According to this information, the villages where the mineral was found are nearly all situated in the tehsil of Rath (approximate latitude 25° 40′ : longitude 79° 40′) in the District of Hamirpur, and it occurred also over an area of about two square miles near Parcha, in the small adjoining native State of Sarila (25° 46′ ; 79° 45′). This State occupies a portion of the same alluvial plain, and is in fact enclosed in the Hamirpur District, the boundary being merely political, and not marked by any natural features.

Regarding the mode of occurrence of the gypsum the information stated that it was found at a depth of from 4 to 6 feet below the surface in the numerous ravines that fringe the high alluvial plain in the neighbourhood of the main rivers, and pointed to the existence of a more or less continuous bed of the mineral. Samples forwarded by the Political Agent in Bundelkhand to the Geological Survey Office were found to be fragments and crystals of selenite, and an analysis made by the Agricultural Chemist, Department of Land Records and Agriculture, United Provinces, showed that they consisted of 99·98 per cent. of hydrated calcium sulphate, $CaSO_4 . 2H_2O$. The Secretary to Government, United Provinces, in a letter to the Director

of the Geological Survey, says that it was sold locally at 12 seers (24 lb) to the rupee, and at 6 seers in Cawnpore. where it was said to be used for sugar-refining, but the Agricultural Chemist suggests that it is more probable that it is employed as an adulterant. As, however, gypsum is not used in sugar-refining, I wrote to the Collector of Cawnpore, who referred the matter to the Superintendent of the Cawnpore Sugar Works, Limited. The latter gentleman repudiates the idea of gypsum being used as an adulterant, on account of its insolubility, which would lead to its speedy detection. The Collector remarks that the *pansáris*, or native druggists, who stock gypsum, say that there is not much sale for it; and that it is solely bought by native physicians.

The receipt of this information caused a considerable amount of interest among the officers of the Geological Survey, for it was thought possible that if the manner of its occurrence were confirmed, the discovery might point to the existence of some of the Lower Tertiary marine beds, corresponding with those of the Subathu group in the sub-Himalayan region, which are frequently gypsiferous, beneath the alluvium of Bundelkhand. So far, no traces of beds of this age have been found along the southern edge of the basin filled by the alluvium of the Ganges and its tributaries, although there is no reason to suppose that they may not exist beneath the alluvium. At the same time it was recognised that the gypsum might have been formed by the drying up of old salt lakes, as in the Bikanir and Jodhpur States of Rajputana, or that it might have been produced sporadically by the action of sulphuric acid, derived from the oxidation of iron pyrites, on limestone, as in Baluchistan and in Burma. An early opportunity of examining the beds in the field was therefore taken, and in November last I visited all the known occurrences of the mineral in the area mentioned above.

The country in which the gypsum occurs is of the usual type met with in the United Provinces and Bundelkhand in the neighbourhood of the larger rivers. These flow in deep, trench-like channels, with high, often vertical banks excavated in the hard kunker-bearing alluvium which spreads over the whole face of the country. The surface of this is nearly level, and at a considerable height above the cold-weather level of the rivers. Along the river courses innumerable narrow, tortuous ravines, clothed with thorny scrub, are cut back into the high ground, forming a perfect labyrinth of broken country extending to a distance of as much as three or four miles from the main stream, without water in the dry season, but becoming rapid torrents during the rains, when the rate at which they wash down and cut back into the fertile lands above must

be a serious matter for the cultivators. This old alluvium belongs to a period of deposition which has now passed away, and it is in all cases being cut into and swept away by the present rivers and streams. The upper surface of it is never reached by the highest floods, but between the high banks stretches of a more recent alluvium, at a lower level, are met with wherever the valley widens out. A good example of the kind of country described may be seen at the crossing of the Chambal river by the railway bridge at Dholpur, and of the Jumna at Agra and Delhi.

A very cursory examination of the gypsum deposits was sufficient to show (1) that the mineral was confined entirely to the older alluvium, (2) that it was found at a more or less uniform depth from the surface, usually about 5 or 6 feet, irrespective of the elevation or position of the locality, and (3) that it did not form a continuous band, or even a succession of lenticular layers, from one locality to another. Any hope of its affording a clue to the discovery of the long sought-for Tertiary beds on the southern shore of the Gangetic basin must therefore be abandoned. At the same time the mode of occurrence of the gypsum is not without interest

On first making enquiries at the villages mentioned by the Collector of Hamirpur, the inhabitants in most cases assured me that the gypsum. which is known locally by the name of "*harsunth*,"[1] did not occur at their particular village, but they all agreed in saying that it was to be found near Puraini (25°45′; 79°50′), a large village lying about 5 miles west of the Bairma river and Parcha, about 3 miles further west in the Sarila State. In all cases, in order to verify the statements of the villagers, I made a careful examination of the sides of the ravines in the vicinity, but without finding a trace of selenite in any of them. A few fragments were also found at the village of Katihri, close to the Bairma to the east of Puraini.

The selenite is in fact confined to a few definite spots, which are well known to the villagers, and is restricted in each case to a very small area. The most important of these is situated at about a quarter of a mile to the west of the village of Puraini, and a description of this occurrence will apply equally well to all those known at present. At this spot the hard alluvium, filled with nodules of carbonate of lime, or *kunkur*, differs somewhat in appearance from that immediately surrounding it. The surface is swollen up into a low mound, consisting of a plastic clay, a

[1] I am not aware of the etymology of this word. The Hindi names for gypsum given in Sir George Watt's Dictionary of Economic Products are *kulnar* and *kurpura-silasit*. *Harsunth* is not to be found in any dictionary to which I have had access.

circumstance that has attracted the notice of the villagers, who call this clay "*gajar mitti*," or plastic earth,[1] and who say that its occurrence is an indication of the presence of gypsum beneath the surface. The selenite is found in this clay at a depth of about 6 feet, in single crystals and fragments up to about 5 inches in length. The crystals are spindle-shaped with sharply pointed extremities, and show no signs of having been transported or rolled, but have evidently been formed *in situ* in the clay. A simple explanation of the origin of the mineral is, I think, afforded by the fact that the clay containing the selenite crystals is more plastic than the surrounding alluvium, and at the same time accounts for its restriction to certain definite spots. These appear to be the sites of what may be called submerged springs, not powerful enough to flow out at the surface, but sufficiently so to keep the superficial layers of the alluvium in a more or less moist condition. The sulphate of lime, due to the reaction of sulphuric acid, derived from the decomposition of pyrites, on the carbonate of lime disseminated through the alluvium, is thus brought up in solution from below, and deposited in the clay near the surface as the moisture evaporates. A sample of water from a well at Puraini, tested in the Geological Survey Laboratory, was found to contain sulphur in considerable quantities, both in the form of sulphuretted hydrogen, and in sulphates.

At this locality the selenite was found to be confined to an area of about 600 square yards, no trace of it being met with in pits dug beyond the limits of the plastic clay, and the pits sunk within this area showed that the deposit was not more than 2 feet thick. It also occurs over an area of about 400 square yards at a spot half a mile to the south of Puraini on the road to Muhammadpur, where it is picked up on the surface after the rains, and to a very small extent in the bank of a small watercourse between Katihri and the Bairma river, about 5 miles to the east. At the Parcha locality, about 3 miles west of Puraini, a pit some 20 feet in diameter and from 5 to 6 feet deep, had been dug by the villagers, and practically the whole of the deposit removed, as I found by digging into the sides of the large pit, when only a few crystals, which had escaped notice, were turned up. As these are the only places where it is known to have been met with in this district, and as it is unlikely, judging from the nature of the deposit, that any more prolific occurrences will be discovered, it is evident that the total quantity of the mineral available is quite insignificant. I was informed that

[1] Perhaps connected with Hindi *guzar*, a fuller or bleacher.

about 12 maunds, or a little over 8 cwt. had already been despatched to Cawnpore, and I question whether there is as much as that still remaining to be extracted.

Another deposit of gypsum, which appears to be of exactly the same character, was referred to in a letter from the Political Agent in Bundelkhand to the Director, Geological Survey of India, in October 1905. It occurs at the villages of Parwar and Barwa, on the left bank of the Ken river, in the native State of Gaurihar, about 20 miles south of Banda (25° 22′; 80° 22′). It is described as occurring on both sides of the river in large mounds of earth, covering an area of 200 and 300 square yards at each village respectively. The earth composing the mounds is soft and quite moist when first exposed to the air, and the gypsum occurs, as at Puraini, in detached crystals, which are picked up from the surface as the soil is washed away during the rains. It is said that a man could collect about a seer and a half (about 3 ℔.) in a single day and it sold in the Banda market at one anna a seer.

# GONDWANAS AND RELATED MARINE SEDIMENTARY SYSTEMS OF KASHMIR, BY C. S. MIDDLEMISS, B.A., F.G.S., *Superintendent, Geological Survey of India.* (With Plates 26—34.)

## CONTENTS.



## I.—INTRODUCTION.

**The Gangamopteris problem in Kashmir.**

EVER since the discovery of Gangamopteris beds near Khunmu in the Vihi district of Kashmir,[1] the question of their exact relation to the Zéwan,[2] Anthracolithic, or so-called Permo-Carboniferous strata in the same locality has

[1] By F. Noetling, first announced in *General Report, Geological Survey of India*, 1902-1903, by T. H. Holland.

[2] See Godwin-Austen, *Quart. Journ. Geol. Soc.*, XXII, 33 (1866), and Verchère, *Journ. As. Soc., Bengal*, XXXV, No. 2, 129 (1867).

been one of the very greatest importance for Indian geology, because of its bearing on the correlation of the great fresh-water Gondwana formation of Peninsular India with the richly fossiliferous marine sedimentary systems of the Himalayan area—two widely distinct geological provinces which up till then had never been found in juxtaposition.

**Recent Workers.**

The papers by Noetling,[1] Oldham,[2] Hayden,[3] Smith Woodward and Seward[4] have done much to solve the question, but it was still felt to be a sufficiently complex and important one for more light to be thrown on it with advantage by further researches. On this account I proceeded last summer to examine the problem once again and to make a detailed stratigraphical study of the surrounding areas. I examined all the old localities; and my results comprise detailed measured sections of those localities in the Vihi plain which had been left without thorough re-examination since 1866. I endeavoured to obtain as representative a series of fossils as possible by collecting to strict horizons, and thus to correlate the sections bed by bed at all the various points visited by me.

**Other discoveries.**

On the way there I was able to revise the geology of a part of the main Pir Panjal range; and whilst crossing this for the purpose of examining some suspected Zéwan exposures, I found a section of great importance in its bearings on the Gangamopteris problem, namely, a more complete and more convincing series of fresh-water deposits containing not only *Gangamopteris*, but *Glossopteris* and several other characteristic, Lower Gondwana plants, and lying definitely beneath those Zéwan beds.

Later on also I was fortunate enough to find a Lower Carboniferous horizon in the Lidar valley, which makes probable an interpretation of the stratigraphical sequence and structural folds there entirely different from that offered by Lydekker[5] in his general work on the geology of Kashmir.

My thanks are due to my colleagues, Messrs. H. H. Hayden and

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[1] *Centralblatt für. Min., Geol. und Pal.*, 129 (1904).
[2] *Rec. Geol. Surv. of India,* XXXI, 5 (1904).
[3] *Rec. Geol. Surv. of India,* XXXVI, 23 (1907).
[4] *Pal. Ind.*, New Ser., II, Mem. 2 (1905), and Seward, *Rec. Geol. Surv. of India,* XXXVI, p. 57 (1907).
[5] *Mem. Geol. Surv. of India,* XXII, p. 136.

G. H. Tipper, the former for many useful hints during the preparation of this paper, and the latter for much assistance in fossil determinations.

## II.—ROUTE INTO KASHMIR.

**Viâ Jammu and Golabgarh.**

For special reasons mentioned in the next section I entered Kashmir by Jammu and the Golabgarh pass. This pass is in latitude 33° 29′ 30″; longitude 74° 50′ 20″, is 12,530 feet high, and is one of the less frequented routes over the Pir Panjal range intermediate in position between the Pir Panjal and Banihal passes.

**Modifications of Lydekker's map.**

The few notes I was able to put together concerning my route across the low hills of the younger Tertiary zone, the limestone belt at the north-east edge of the latter and the Panjal slates, schists and gneissose granite which form the outworks of the higher range as far as Golabgarh, are not of any special interest as regards the main subject of this paper. I shall, therefore, omit all account of them here and limit my remarks to a brief reference to the strata as found in the Golabgarh valley itself and on the ascent from there to the pass, where important modifications of Lydekker's map have been rendered necessary.

**Anticline in the Panjal system.**

Instead of the Golabgarh valley and the 4,000 odd feet from it to the pass being in metamorphic or gneissic rocks, I found the former to be cut out of an immense anticlinal of Panjal slates, angular conglomerates and quartzites, whilst the upper limbs of the anticlinal, one of which forms the steep, cliff-like ascent to the pass, I found to be wholly composed of a very great thickness of massive Panjal traps, frequently amygdaloidal. This anticlinal is illustrated in the view (Pl. 26), which is taken from the neighbourhood of Golabgarh Arital and near wnere the ascent begins.

As Lydekker in his memoir (*op. cit.*, Vol. XXII) makes no special reference to this place I can only conclude that his mistake as to the constitution of the main range there was due to his having only seen it from a distance, a quite likely supposition since the massive aspect of these Panjal volcanics certainly simulates that of a gneissic rock. It is true that some way below Golabgarh in the

neighbourhood of Dowal (Dewal) and Angril (Angrala) bands of gneiss or gneissose granite are met with penetrating what must be called for want of a better term, Panjal slates, causing readily apparent extra metamorphism of the same, but all such beds are comparatively thin, and finally end before the N.W.—S.E. uppermost reach of the Golabgarh stream is reached.

That Lydekker never crossed the Pir Panjal at this point seems indeed additionally evident from the fact that he has not recorded from there any of the younger fossiliferous series, although, as will be described in the next section, a well-exposed synclinal of them lies axially on the pass itself—a feature which it would be impossible for a geologist who had been there to overlook.

## III.—GOLABGARH (KURI) PASS SECTIONS.

**Fossils sent by Mr. A. Campbell.**

It was in consequence of specimens sent to the Geological Survey Office by Mr. Allan Campbell, Assistant Engineer to the Kashmir Railway Survey, in the month of February 1905, and which were determined by Mr. Pilgrim as *Productus*, *Lyttonia*, *Protoretepora ampla* Lonsd., *Spirifer Musakhelensis* Dav., and *Spiriferina* sp. cf. *Kentuckensis* Shumard, and typical of the Zéwan beds, that I entered Kashmir by way of this pass, so that I might examine them more fully, especially since, from his work in Vihi, Mr. Hayden thought it not unlikely that the Gangamopteris beds might also be found in connection with them, a supposition which, as already stated, I was able to verify beyond all expectation.

**Syncline of Zéwan beds above Gondwanas.**

The marine Zéwan beds were found without any difficulty from Mr. Campbell's description of their occurrence, but instead of being interbedded with the Panjal volcanics, as was supposed by their discoverer, I have established that they lie in a tight synclinal fold among those volcanics, and superposed on the plant-bearing Lower Gondwana strata.

**General strike.**

Their general strike is N.W.—S.E., but at the pass itself N.W. by N. and S.E. by S., with a well shown dip on the N.E. side of the syncline of 63° S.W. by W. as taken at the basal conglomerate. The syncline thus strikes diagonally across the pass

and across the descending ridges which meet to form the pass in a W.—E. line.

**Poor sections south of the pass.**

On the south side of the pass the country slopes gently for about a mile, and then descends sharply to Golabgarh in a series of crags and steep slopes in the Panjal volcanics. The change occurs at the incoming of the Zéwan or Permo-Carboniferous syncline. Owing to this flattening of the ground immediately south of the pass and the consequent litter of fragments scattered all round, the junction of the younger rocks with the traps is not actually well seen along the line of route. But across the valley looking east, just where the steepening begins one can see clear signs of the Permo-Carboniferous rocks setting in on the top of the volcanics.

**Sections on north side of pass.**

On the north side of the pass the ground drops rather suddenly for a few hundred feet and save for a few snow slopes hiding portions of the section (in July) there was a clear exposure of all the rocks with the exception of the junction and lower part of the younger series on the S.W. of the syncline. These exposures are either on the actual pass and composing hill spurs which meet there, or on the north slopes below the crest of the pass (see Pls. 27 and 28).

To the N.W. of the pass on the minor spurs descending N.E. towards Gogalmarg additional sections are seen which will be described later. They help to fill in details of the section on the S.W. side of the synclinal.

**Extension of the synclinal N.W. and S.E.**

In the distance, viewed from the pass, the outcrop of the synclinal of the younger series can be seen to continue, probably with increased or equal strength, in a S.E. direction among the high slopes and ridges for certainly over a mile. I should anticipate that in this direction the syncline with good exposures would continue for some way beyond that, but I was unable to explore further in this direction owing to monsoon conditions (which were heavy at that side of the pass), and also owing to my camp being at Gogalmarg, some 2,000 feet down on the Kashmir side of the pass. For that reason every day I had a two hours' walk before I could begin work and one hour for returning. A suitable time for exploring the S.E. continua-

tion of this syncline would be a little later at the end of the rains and before the winter sets in. It should be approached, however, from the Kashmir side as the long and tedious journey from Jammu should be avoided if possible by any future explorer.

As regards the N.W. continuation of the syncline, the strike must take the outcrop down the S.W. side of the Chitti N., but inasmuch as already in the near secondary spurs the heart of the synclinal so exposed was only showing lower beds, and inasmuch as old moraines spread out right down to the Chitti N. where lower and lower depths are constantly being reached, I do not anticipate any further exposures—unless perhaps the ridges near Sitpoor Station, 9,840 feet, may give such—in that direction where they must eventually disappear beneath the Karewas near Sedau and Khazanabal. I should have liked to follow along this route to Srinagar, but the monsoon and melting snow had destroyed the numerous bridges on this route, and I had perforce to proceed *viâ* Nandmarg (Nanmarg) and Kulgam.

## 1.—General Sequence in the Syncline.

**General sequence in ascending order.**

The general sequence of strata in the synclinal in ascending order is (1) a basal conglomerate lying on the Panjal trap and ash beds, (2) a series of siliceous shales, quartzites, carbonaceous shales and sandstones with a Lower Gondwana flora, (3) soft earthy calcareous sandstones and limestones with a typical Zéwan fauna with many divisions identical with those in the Guryul ravine section (see p. 293), (4) a thin-bedded, blue-grey limestone forming the core of the synclinal on the ridge west of the pass. No fossils were found in the latter, but from its resemblance in composition and position to similar beds in the Guryul ravine it is not improbable that it may really be of Triassic age.

The whole set of rocks, from their sometimes dark colour and generally thin-bedded condition, contrast well with their setting of massive, frequently pale weathering beds of the enormously thick Panjal volcanics.

## 2.—Details of the Beds.

### *Basal Conglomerate (V).*

This is a strong, well consolidated bed containing pebbles,

frequently rather flattened and reaching the size of racquet balls. The bed is a compacted mass of those pebbles and about 6 feet thick on the crest of the east ridge connecting with the pass. The bed is so strong that it forms a wall-like mass towering above the succeeding siliceous shales and sheeting the underlying volcanic rocks. The contained pebbles are chiefly compact grey chert-like rocks. Others are dark slate fragments, with a sprinkling of small quartz grains. There is no indication of unconformity with the underlying traps.

*Siliceous and Carbonaceous shales.*

(V-1, V-2, V-3, and V-4.)

These follow above the conglomerate and are thin-bedded, buff coloured, siliceous, compact rocks, interbedded with grey shales or fine ash (?) and carbonaceous shales. The former are hard and platy and may be chert, ash or even felsitic, but they suggest hardened and silicified shales. They are about 180 feet thick.

*Hard grey Sandstones and Carbonaceous shales.*

(W, W-1, and X.)

Next follow—all in apparent normal sequence—400 feet of very characteristic beds, being hard, grey sandstones, sometimes almost quartzitic, fine-grained and interbedded with numerous shaley horizons. There are also occasional white quartzite layers (not novaculite). Near the base of these an inconspicuous pale shale (W-1) about 5 feet thick, rather soft and weathering easily, and marked on the slope below the crest by a particularly well seen bright primrose-coloured lichen, yielded the first horizon with plant remains. It outcrops up the slope a little below and east of a prominent V-shaped gap on the crest of the ridge (see Pl. 27). The inconspicuous nature of this shaley band made me miss it until, after coming across a fallen weathered fragment full of fossils, I tracked the latter to its home and found it *in situ* on the slope.

This band is crowded with, sometimes well-preserved, plant remains, mainly *Psygmophyllum* (?) in many-leafed groups attached to one stalk, some examples of *Gangamopteris* cf. *cyclopteroides* Feist

and a few of *Glossopteris* cf. *communis* Feist. The rest of the section up to, but not including, (X) consists of repetitions of the somewhat hard and splintery sandstones and shales, among which plant impressions appear to be scarce, and good fossil horizons certainly absent.

With bed (X) we reach a rather prominent, hard and compact, black shale, 20 feet thick, standing protrusively from the rest of the section, and especially well seen on the slopes. (It is not well seen on the crest.) The shale splits readily under the chisel into flat slabs, and it is sparsely fossiliferous, the best specimens being found near the base of the layer. Its position in the photograph (Pl. 27) is indicated by a small isolated patch of snow under a gap in the crest to which the bed outcrops up the slope. Here *Glossopteris* is the prevailing genus, chiefly *G. communis*, but one specimen I identify with *G. decipiens* Feist. There are also numerous examples of *Vertebraria indica* Royle, and some other undetermined fragments of plants.

The above two plant horizons make certain conclusions of a general nature possible :—

(1) The general association of plants in the lower one (W-1), including the prevalence of *Gangamopteris* and the rarity of *Glossopteris*, suggests a Talchir homotaxis for it. In the case of this horizon, however, the bed was so fragile that I brought away samples of it in a few large pieces, the splitting up and development of which I preferred to leave to the expert who eventually will examine them critically. Hence my conclusions may possibly be far from exhaustive.

(2) The upper bed (X) on the contrary, with its pronounced *Glossopteris* flora, and especially the species *G. decipiens*, which is regarded as a passage form between *Gangamopteris* and *Glossopteris* and does not range as high as the Damudas, suggests a Karharbari horizon for that bed (if my specific determination be correct).

In any case it seems certain that these 400 feet of carbonaceous shales and sandstones should be homotaxially grouped with those near the base of the Lower Gondwanas of the Peninsular series, even though there is no sign here of any glacial boulder beds which are so distinguishing a feature of the Talchirs of Southern India as well as of the Middle Carboniferous of the Salt Range.

### *Earthy sandstones (calcareous above)* (*Y*).

The next beds in the section follow as if uninterruptedly and perfectly conformably, being visible like all the preceding from the crest—where they make a rather prominent bulge — right down to the bottom of the slope. They are rather massive, soft, light coloured, earthy, sandstones. becoming calcareous above in lenticular patches, by which they pass up into the next stage. Their thickness is about 230 feet.

### *Protoretepora Limestone* (*Z*).

This is the most fossiliferous of any horizon in the section The lower part (Z-1) is rather more sandy and shaley and is characterised by brachiopods which are compacted into the rock and an absence of *Protoretepora.* Among them is a *Productus* allied to *gangeticus* Dien., or *Purdoni* Dav., and a (?) *Rhynchonella.* Horizon Z-2 coming above the last consists of thin-bedded slabs of dark, fœtit limestone, showing many and beautiful plumes of *Protoretepora ampla* Lonsd.; *Spirifer fasciger* Keys. (*musakhelensis*), *Camarophoria* cf. *Purdoni* Dav., and *Lyttonia* are also represented. The whole thickness of the series is about 200 feet, but it was difficult to gauge accurately as the lower parts were only seen along the crest of the ridge just east of the pass; whilst the northern slopes were entirely covered up at the time of my visit by a thick bank of snow along which part of the pathway led (see Pl. 27). Although the fossils are not generally well preserved in this stage, I think a better collection than I was able to secure could be got at another time of year when the slopes become clearer of snow.

On the face of it there can be little doubt about this fauna being a typically Zéwan one, identical with that of the Zéwan spur of the Vihi sections — an identity emphasised also by the general sequence, faunistic and petrological, of it and the next succeeding beds.

### *Black Shales* (*A*).

These are not well seen, but there is a trace of them on the ridge close to the pass, and others at the lower part of the slope below and N.W. of the snow bank. The latter, however, is not quite certainly in place.

*Earthy micaceous sandstones (B).*

Lying to the west of the actual pass and rising above the snow slope which conceals (Z) and (A) comes a rather massive soft earthy, micaceous, greenish-coloured sandstone with casts of fossils here and there. It is 300 feet thick and resembles (Y). The pathway in part zigzags down this to avoid the snow on the steeper slope. A small *Marginifera* was recognised in them.

*Black Shales (C).*

This is a thin band 10 to 20 feet thick and standing up rather prominently just before a gap in the ridge. With it are some lenticular patches of limestone with *Spirifer Rajah* Salt., etc.

*Blue-grey Limestone (D).*

Thin-bedded light blue-grey limestone follows forming the core of the synclinal and rising up the western ridge above the pass. It shows a gradually steepening dip, with much crushing, and fossils are absent or very scarce. It probably represents the Trias of other sections.

## 3.—Other Sections near the Pass.

Above the point on the ridge last described the section begin to repeat itself to the west and south. Bed (B) is clearly seen, but above this the crest and slopes are much covered by talus and nothing is clear.

Another section, however, is provided of this side of the synclinal by the secondary spur which descends from the high hill mass west of the pass. It descends from the 2nd "A" of the word "SAKAL" on the Atlas of India sheet 29 N.E. and skirts the N.W. side of the little glacier (see Pl. 27) on its way north towards Gogalmarg. There is a rather obscured section in the sandstones (Y) and limestones (Z), which latter form the core of the fold there. The S.W. side of the fold shows traces of the conglomerate, whilst pieces of shale and hard sandstones (the former with plant impressions) can be picked up on a grass-covered slope representative of beds (V) — (X). The base of the N.E. side of the fold is hidden under moraine and rubbish heaps along this secondary spur.

Looking S.E. from this point to the pass and main ridge to the west of it, the nearly vertical, and possibly partly faulted, nature of this side of the synclinal is clearly seen.

*Northern side of the Pass.*

The encircling ridges and spurs leading down N. and N.E. from the pass to Gogalmarg and beyond there to Nandimarg (Nanmarg of the map) show a great repetition of the very thick and massive Panjal volcanics, interbedded here and there with a few slates and quartzitic rocks, dipping steeply to the S.W. and forming the N.E. limb of the grand synclinal fold that has its axis in the younger strata at the pass. These volcanics in fact occupy all the area marked on Lydekker's map as Panjal slates from the pass to near Nandimarg. Only in the lower parts of the valley, shortly before the sub-recent Karewas set in, do Panjal slates, quartzites and angular conglomerates appear.

## 4.—General Results from the Pass Sections.

Taking the synclinal fold as proved, there are one or two other points about the section that require attention drawn to them. In the sequence of strata just described it is clear that from the conglomerate (V), lying on the volcanics, up to the presumed Trias in the trough of the syncline, there is no sign of any discordance, either in the lie of the rocks themselves or in the sequence of the sedimentary material of which they are composed. A perfectly normal, consecutive superposition of the beds, passing by gradation from one into the other, without any stratigraphical break and without any sudden variation in the angle of dip, is manifestly the correct and only possible interpretation of the section.

It only remains to point out that, if the identification of the plant-bearing beds with the Talchir and Karharbari stages of the Lower Gondwanas is warranted, it becomes evident that the latter in their Peninsular development must now take their absolute stratigraphical position in the world-sequence from the marine beds lying a short distance above their Kashmir equivalents, namely, the *Protoretepora ampla* Lonsd., horizon of the Zéwan beds. *P. ampla* is an Australian bryozoon typical of the Gympie or Lower so-called Permo-Carboniferous of Queensland, and not found passing

up into the Star or Bowen series of younger Permo-Carboniferous age.[1] In this connection it is interesting to note that my correlation of the Golabgarh plant beds with the Peninsular Talchir and Karharbari horizons, on the evidence of their contained flora, is therefore indirectly verified by their being associated with beds containing *Protoretepora ampla*, since the latter in Australia marks a series characterised by an unconformity below and by its containing glacial boulder-beds—just as is the case with our Indian Talchirs.

Exactly as to why this Talchir facies of the rocks of the Golabgarh pass is wanting in evidence of those widespread glacial conditions, one cannot say; but it seems to be undoubtedly so, as also is the case with the sequence of purely marine beds of about the same age in other parts of the Himalayas, whilst as pointed out by Sir T. Holland,[2] we are relieved from the necessity of considering the undoubted glacial beds of the Blaini in the Simla sequence to be a Talchir facies of identical age (for which there is no fossil evidence whatever) in view of the much older widespread glaciations of Asia, Australia and South Africa now known to have taken place in Cambrian or at least Pre-Devonian times.

## IV.—KASHMIR VALLEY—VIHI DISTRICT.

The Vihi district lies on the right bank of the Jhelum river one march above Srinagar. The Zéwan strata as there found together with the underlying traps and overlying Trias, etc., are therefore separated from the Pir Panjal outcrops just described by the wide deposits, both recent and sub-recent (Karewas) that occupy the intervening river valley. A noteworthy feature is the way the strike wanders about—twisting and turning on itself in a manner foreign to Himalayan geology. By some cause, not fully understood, the regular N.W.—S.E. flexuring of the mountain mass appears to have been hindered or complicated by other tendencies, and the result is a rough basin-shaped arrangement of the Carbon-Triassic group of rocks here with, as one may say, crinkled edges.

References to the original workers in this area have already been made in the Introduction, and I shall now proceed to describe

[1] See Jack and Etheridge, *Geol. and Palæontol. of Queensland*, 1892.
[2] *Rec. Geol. Surv. of India*, Vol. XXXVII, pt. 1, p. 132.

a few of the chief sections in detail, freely illustrating them with sections, diagrams and sketches, so as to bring out as graphically as possible the relation of the various fossil zones to one another. It is only to be regretted that the want of a large-scale map prevents me from making this aspect of the subject still more complete. I have introduced, however, a sketch plan of the area whereby the geographical position of the various spurs where individual sections are taken may be readily grasped (Pl. 31).

## 1.—Zewan Spur.

The full sequence of this classical locality has been recently redescribed with a diagram section by Hayden (*Rec. Geol. Surv. of India*, Vol. XXXVI, part 1, 1907, with Plates 4 and 7). In it he recorded finding specimens of *Gangamopteris* in the shales below the Zéwan marine strata.

I worked through the entire series without making any new points, except perhaps that Hayden's beds 23 and 24 seem to be interbedded with each other, and not to occur separately. It is a little difficult to be certain on account of the dip being almost with the slope, the actual amounts being 40° S.S.E. in the direction of Zéwan village. These beds form the uppermost visible in the section. They may be described as a dark grey, massive limestone, full of compacted shells and with thin partings of greenish shale. The former has wavy or undulating surfaces like irregular ripple-marks [bed (1) 1-8-08], and is being extensively quarried for building purposes in Srinagar. Among the compacted shells *Athyris* is prominent and a small cordate *Productus*. The thin partings of greenish and black shale (2) 1-8-08, contain *Spiriferina* cf. *Kentuckensis*, *Athyris*, *Protoretepora ampla*, *Lyttonia*, *Productus* and a branching bryozoon, *Thamniscus* sp. About 30 feet of these beds are exposed, and they are probably about the horizon of the *Protoretepora* beds of the other more complete sections which are about to be described.

## 2.—Risin Spur.

I walked over this section, getting abundant examples of *Gangamopteris*, but nothing new. It has been described by Noetling, Oldham and Hayden, and, although isolated from the marine Permo-Carboniferous beds, its connection therewith has been clearly proved.

The fauna and flora are described by Messrs. A. Smith Woodward and A. C. Seward (*Pal. Ind.*, New Series, Vol. II, Mem. 2), and photographic views of the spur are given in Hayden's report (*loc. cit.*, Pls. 5 and 6).

Having already described the similar but more convincing section of Gondwanas beneath marine Zéwan strata in the Golabgarh pass, it is no longer necessary to elaborate further proof of this, and I may therefore now proceed to describe bed by bed the sequence of the fossiliferous horizons of the Carboniferous, Permian and Trias in the Guryul ravine, as they may now be presumed to follow in regular sequence, above the fresh-water Lower Gondwana sediments.

## 3.—Guryul Ravine and east of it.

I paid particular attention to the section exposed in this ravine, which descends from the north towards Khunmu, because it had not been fully treated of in the reports of my predecessors, Hayden in particular having only been able to devote a day or two to it.

Hayden's photograph (*loc. cit.*, Plates 1 and 5) and my camera lucida sketch (Pl. 29) will give a general idea of the gorge and the beds exposed The section is in every way an excellent one and merits close description. Two upper branches of the ravine unite into the main ravine which divides the Panjal volcanics on the left from the sedimentary Carbon-Trias on the right. Those on the left form great dip slopes, those on the right prominent scarps of alternate cliff and slope.

At the entrance to the gorge a group of two or three *Chenar* (plane) trees makes a prominent landmark whereby the place can be recognised from afar.[1]

Just at the level of the lowest Chenar tree one of the best fossil horizons in these rocks (1) 2-8-08 comes to the surface, but the actual base of the marine deposits is only found a few hundred yards higher up the ravine, just below where the two upper branches of it meet. From the latter point the following section (see Plate 30) was gradually pieced together. On account of the steepness

[1] The place is convenient for a small camp, but unfortunately is infested with snakes. After spending some days there I had to retire to Khunmu village as my servants were getting nervous after killing several.

of the scarp the various points had to be reached by scramble up accessible parts of the slopes and traverses parallel to the outcrops. Of the older observers, Godwin-Austen has depicted a portion of the section (*loc. cit.*, p. 34), whilst Verchère seems to have referred to the same in his interesting but rather fanciful section beginning with the spurs over Zowoor (*loc. cit.*, p. 160).

*Novaculite.*—The lowest bed lying directly above the Panjal volcanics is here seen to be Hayden's novaculite. a white cherty, very compact rock which that author has clearly shown to be a metasomatic replacement of limestone (*loc. cit.*, pages 29-30). There are from 6 to 10 feet of this. This and all the succeeding series dip at 30° E.S.E.

*Siliceous rocks.*—Above the novaculite the representatives of the *Gangamopteris* beds just here are not very thick nor well exposed. Hayden's locality where a frond of *Gangamopteris* was found by him actually in these rocks is some hundred yards or so higher up in the bed of the right-hand stream above the junction. The exposures here are dark, compact and siliceous rocks, and black shales, occupying the hollow between the novaculite and the next scarp of limestone.

*Dark grey Limestone.*—Next follows a little scarp of dark grey, rather sandy limestone with shaley partings. It is from 50—60 feet thick. Obscure compacted layers of brachiopods are represented, but nothing in a good state of preservation could be extracted.

*Fossil Horizon* (1) 4-8-08.[1]—Above the crag just described a slope begins with shales and interbedded limestones, the first of the latter is a band about 10 feet above the limestone scarp a few inches to 1 foot thick only, of a dull grey colour, and full of specimens of *Notothyris*, Waag., or *Hemiptychina*, Waag., with few *Athyris* sp.

*Protoretepora shales and Limestone.*—Dark sandy shales and thin interbedded limestones full of *Protoretepora* colonies, one above the other, now succeed and are about 30 feet thick.

[1] NOTE.—None of these or subsequent field numbers follow in numerical order. They simply record the number and date of the specimen found, irrespective of the particular sequence of the rocks. This saves confusion in numbering when fresh horizons require interpolating between old numbers. Their use is solely to define the particular horizons in the diagram sections to which specimens so numbered belong.

*Fossil Horizon* (1) 2-8-08.—A very well marked band of grey limestone, very like (1) 4-8-08, with well-preserved brachiopods, chiefly *Athyris*, follows. It is about 1—2 feet thick, and lies near the foot of the next steep scarp. But the same bed is continued and much better seen at the entrance to the Guryul ravine at the group of Chenar trees. There the fossils stand out on the weathered surfaces and collecting is easy. From this horizon were obtained *Athyris* cf. *Royssii*, Lév., over 200 specimens, all from the same bed, were gathered, of great variety of form, some being broad, others long, some flat and some globose. All appear to be varieties of one species. A few specimens each were found of *Productus* cf. *gangeticus*, Dien, or *Abichi*, Waag., *P. semireticulatus*, Mart., *P.* cf. *cancrini*, Vern., *P.* sp., *Camarophoria* (a small form cf. *Purdoni*), *Spirifer* sp., *Dielasma* cf. *acutangulum*, Waag., *Dielasma* sp. and one Gastropod and one Lamellibranch, *Posidonomya* (?).

*Dark sandy Shales.*—Next follow, forming a cliff or series of steps, 280 feet of dark soft, sometimes calcareous, sandy shales or shaley sandstones, micaceous and slightly carbonaceous. This is a very characteristic rock. It builds sometimes massive, but always splintery and wavy-bedded crags. It is petrologically very similar to the series above the *Protoretepora* beds in the Golabgarh pass. Hayden has already remarked on it being similar to the *Productus* shales of Spiti, only more sandy. In the section here and at other places to be described later, it stands out particularly as crumbling bare cliffs, and helps to give the character recognisable at a distance to the Carbon-Trias of this part of the Himalayas. A very similar bed is repeated at a higher horizon among undoubted Trias [see (B) 6-8-08].

In the lower layers it passes by means of a few interbeddings of limestone layers down into the series below with (1) 2-8-08. A few traces of brachiopods are recognisable in them, but nothing good was found. In its upper layers it becomes more calcareous, passing gradually into the next set of beds.

Although I found nothing worth collecting in them, Hayden has recorded *Marginifera Himalayensis* in collected patches followed by others containing *Pseudomonotis* and *Spiriferina* cf. *Griesbachi*, Bittn., from the upper layers of this stage.

*Shales and thin-bedded Limestone.*—The upper part of the last crag or scarp shades off into a slope with a marked saddle in

it, the latter being especially well seen on the spur descending to the Chenar trees at the mouth of the gorge. This marks the interbedding of a series of shales and thin bedded limestones, about 100 feet thick, and with one markedly fissile, black shale band 10 to 20 feet thick, occurring just in the bend of the saddle. The latter contains hardened concretionary masses with small iron pyrites crystals (2) 9-8-08.

*Beds* (1) 9-8-08 *and* (1) 7-8-08.—At the top of the last slope along the spur comes the bed (1) 9-8-08 just at the foot of the nearly vertical wall of thin-bedded limestones that forms so marked a feature in the hill outline. It is a rather dark grey limestone and contains a small species of *Pseudomonotis* in small crowded patches. This bed may be the same as the one mentioned by Hayden and referred to under the last heading but one.

About the same horizon, but lower down on the slopes of the spur, and near where the vertical cliff above ends in the talus fan, is horizon (1) 7-8-08, containing (?) corals and *Pseudomonotis*, etc.

It is probable that the Permian series ends here, or somewhere here. Hayden has mentioned the finding of a band of hard limestone with *Danubites*, *Flemingites* and *Bellerophon* near here, or perhaps at a slightly lower horizon, and as will be seen later the next fossil zone found by me in the next saddle above the vertical crag contains many Lower Trias cephalopod forms and lamellibranchs.

*Lower Trias* (?).—A steep, almost vertical cliff of hard, thin bedded limestones with hard shaley partings follows next. It is about 100 feet thick, but its height varies at different places along the scarp. It may be recognised in the camera sketch by its pronounced wall-like aspect, and, on the nearest secondary spur running down to the Chenar trees, by its following above the pronounced saddle and slope. At one point it breaks up into two crags, the upper one being of secondary importance.

No fossils at all were detected in this homogeneous band, in spite of two traverses right across it up a rift and also round its southern end where it disappears under the fan deposits bordering the Vihi plain. It is the band that Hayden has referred to (*loc. cit.*, Pl. 5 and p. 34) as possibly muschelkalk, but from the sequel it will be seen that this suggestion cannot be maintained, the more probable representatives of the Middle Trias being still higher up in the section (see p. 297).

*Lower Trias Fossil Horizons*, (1)—(4) 6-8-08.—Next follows a slope, partly lying obliquely across the uppermost of the last described beds, but including a minor little wave or undulation which imperfectly exposes some more thin limestone beds and shales containing cephalopods. They are best seen about midway between the bottom of the hill (where the talus fans begin) and the first saddle on the subsidiary spur. The exact spots are indicated on the camera sketch and section. Each horizon is separated from the other by from 10 to 20 feet of unproductive shales so that the thickness of the whole series is about 40 to 50 feet. There is generally but little trace of any fossils on the surface of the limestones—though occasionally one meets with weathered surfaces showing outlines of ammonoid forms. Here, as all through these exposures, it was only by breaking every foot of seen rock that the fossil zone was detected. The forms represented at horizon (1) 6-8-08 are *Pseudomonotis* sp. and numerous examples of rather small ammonites whose general shape and sutures mark most of them as belonging to the *Meekoceratida*. Among them are *Meekoceras* cf. *Lilangense*, v. Krafft, *Meekoceras* sp., also *Danubites* of the group *Purusha*, Dien., one small *Nannites*, and some fragments of large, smooth, sharp keeled undeterminable ammonites which may however be *Hedenstrœmia*. I hoped to have got a better collection from them and the succeeding beds, but the rock does not break easily and extraction of the fossils whole was very difficult.

From the next horizon, (2) 6-8-08, a few forms of *Meekoceratidæ* with auxiliary sutural elements, and agreeing with *Meekoceras* (*Koninckites*) sp., Dien., also a few very small ammonites with very broad, flat ventral margins, and one *Orthoceras* were found, in addition to *Pseudomonotis* sp., *Meekoceras* cf. *Lilangense*, *Meekoceras* sp. and *Danubites* as in (1) 6-8-08. Nothing noteworthy was obtained from the beds (3) and (4) 6-8-08.

It seems probable that these beds represent the Meekoceras horizon of Spiti and the Kumaun and Garhwal Himalayas, and therefore that the two lowest Trias horizons, namely, those of Otoceras and Ophiceras are missing in the section or else have not been detected by me. A Lower Trias age at least seems certainly indicated.

Next follows another steep, but smaller doubled crag of unproductive limestone, very similar to the last. Its dip-slopes

plunge down into the next little stream-bed east of the Guryul ravine. Lower down the same beds cross the stream where it curves in a westerly direction and reappear on the east slopes of the next subsidiary spur. They are hard, dark and of a blue-grey colour, thin-bedded, and with partings of silicified shale which stand out in relief. The upper crag is ochre-coloured in places at the junction with the sandy shales next described. Nothing was found in these beds but a piece of fossil wood 2() 7-8-08, and some layers of compacted shells from which nothing was extracted.

*Sandy Shales with subordinate Limestones* (*Muschelkalk* ?).—Above the last-described and following on in the regular section come some sandy shales which, though only imperfectly exposed on the slopes in the higher parts of the stream-bed, become more prominent in a little straggling spur running out towards Khunmu in a S.S.W. direction. This little spur stretches out far in advance of its neighbours into the plain among the talus fans, and in the drawing is marked (B) 6-8-08. It is noticeably bare of vegetation.

From the similarity of the rock to the sandy shales (Permian) or the Guryul ravine, I was at first inclined to think that they might be a repetition of the latter by faulting, but subsequently I found the same beds continuing up the stream and building the lower slopes of the next series of numerous and steep scarps: and, besides, their fossil contents are dissimilar. I have therefore no doubt that they continue the whole way up to, and cause, the great saddle on the main ridge, shown in the camera sketch as lying directly above and in a line with the east branch of the Guryul ravine, and in a direction due north of the western Khunmu and therefore that they enter the section definitely superposed on the Lower Trias.

The rock is a dark sandy micaceous shale, calcareous in bands which are more scarce in the lower parts, and more numerous in the higher beds where this stage merges into the great limestone crags which follow. Altogether it is about 200 feet thick although in its lower extremity the spur only shows some 60 to 100 feet of the lower beds (see lower part of section). The dip varies from E.N.E. 30° in the higher parts to E.S.E. 30° at the lower end of the subsidiary spur. This change of strike, especially rapid in the lowest part, seems to be a hint that all the similar spurs west of this do the same just about where they

disappear under the talus slopes bordering the Vihi plain. This bending and splaying out of the bands towards the plain explains the fact that the Risin and other spurs to the west catch fragments of the Permo-Carboniferous, and the fact that further south near Weean much higher beds of the great limestone come in. In the camera sketch this tendency to bend and spread out can be detected.

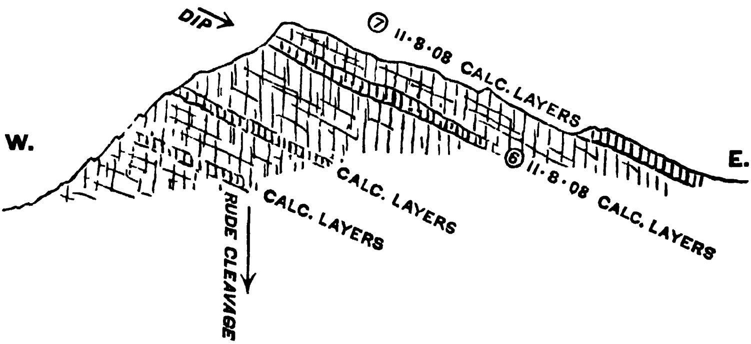


FIG. 1 —Muschelkalk spur N.N E. of Khunmu.

A marked feature in these sandy shales with subordinate limestones is that a rude cleavage makes its appearance with a N.E. by E.—S.W. by W. strike and nearly vertical. The beds are so feebly compacted and the rock so comparatively soft that this attempt at cleavage is extremely rugged, the planes being vacillating or undulating and not finely approximating as in ordinary slaty cleavage (fig. 1). At first sight it almost resembles vertical bedding (see Verchère, *loc. cit.*, page 161, where he apparently refers to this spur).

The calcareous horizons are fossiliferous, the zones (6) 11-8-08 and (7) 11-8-08, which come about the middle of the series, being especially so. Both the latter catch portions of the surface slopes at the lower end of the spur. Fossils are, however, not numerous, and owing to the cleavage have been very generally distorted. From (6) 11-8-08 I obtained a number of small brachiopods in a layer of about 1 foot thick. Among them were a large number of *Rhynchonella* cf. *trinodosi*, Bittn., and cf. *mutabilis*, Stol., together with a few *Spiriferinæ* cf. *Stracheyi*, S lt. From (7) 11-8-08 I obtained some lamellibranchs and one aammonite *in situ*, whilst

I picked up from the weathered-out talus close by *Ceratites* cf. *Thuillieri*, Oppel, *Pinacoceras*, *Nautilus* and *Orthoceras*.

From higher up the spur at the locality marked "near (7) 11-8-08" I obtained many more lamellibranchs, *Lima*, *Posidonomya*, *Myophoria* (?) and others; also (?) *Patella*. Here also gradually come in higher beds, limestones predominating of 1, 2 and 3 feet thickness until they finally merge into the main mass of the next great limestone series.

*Thick Limestones* (*Lydekker's Supra-Kuling*).—Beyond the last spur the ascending series of massive limestones stretching away to the east were only cursorily examined for a mile or two along the edge of the plain. No good fossil zones were found. On the ridge spur next beyond that referred to as (B) 6-8-08 there is a pale crinoid and coral limestone, the remains being compacted together into an indistinguishable mass (1) 8-8-08. The locality is N.N.E. (a trifle E.) of Khunmu. Between the two ridges there is nothing recognisable, though beds with compacted shelly contents occur. (2) 8-8-08 a rock similar to (1)—is from the stream-bed beyond the last ridge near another group of Chenar trees (see extreme right of the camera sketch). (3) 8-8-08, ¼ mile further on contains a (?) *Rhynchonella*. (4) 8-8-08 from the ridge N.E. by N. of Khunmu contains *Spiriferina* sp. and (?) *Dielasma*. Beyond this, enormous thicknesses of similar rock continue, but complicated by repetitions and flexures in a way that would require much time and large-scale maps to elucidate. No further work was continued in this direction.

## 4.—General Remarks on the Section in the Guryul Ravine and E. of it.

The section just described, like that in the Golabgarh Pass shows no sign of unconformity, no discordance of dip and no rapid petrological changes. It suggests one uniformly accumulated set of deposits that have arisen without any marked time-breaks.

Nevertheless the very thin development of the Gangamopteris beds, as compared with those at Risin, Zéwan and the Golabgarh Pass, is suggestive at least of some overlap, a suggestion heightened by the fact that in the Guryul ravine some ½ to ¾ mile above, the point described by Hayden I found the Protoretepora bed directly superposed on a cliff of Panjal volcanics, or with a mere trace of novaculite between. The spot is just where the cattle path

crosses the east branch stream on the way up to the high pastures. The siliceous shales and lower massive limestones, seen at the lower part of the ravine, seem to have been overlapped. From the clear way the one rock follows above the other, dipping at the moderate angle of 30° only, I do not think that faulting has come into play here—and more especially as other sections south of the Vihi plain show a complete absence of Gangamopteris-containing and similar beds, whilst nowhere in the area is there anything approaching the large thickness of 800 feet of such rocks as found in the Golabgarh Pass.

As regards the stratigraphical horizons identified in the preceding paragraphs, Upper Carboniferous and Permian seem amply certified to. The Lower Trias (first recognised fragmentally by Hayden) is equally demonstrated to occur, though with few characteristic fossil zones and with many omissions. The large and unusual thickness, however, of the beds which seem to be included within this stage inspire one to hope that further researches in the neighbouring ravines and scarps might bring to light a fuller zonal sequence. At all event the long-supposed absence of Lower Trias in Kashmir[1] has now been definitely found to be a misconception, as was to be expected following on the successive identification of Lower Trias in the Garhwal and Spiti areas.[2]

The evidence for the existence of Middle Trias (Muschelkalk) is less good though strong.

As regards still higher Trias horizons, it is to be feared that the beautiful fauna characteristic of other Himalayan areas is not to be found in this section. But in view of what has recently been accomplished in unpromising-looking strata for the lower divisions of the Trias, one need not yet utterly despair of success so long as great thicknesses of unsearched limestones still remain.

It will be noticed that, contrary to what Verchère found in this section, I discovered no serious irregularities (refolding or faulting) until well beyond the beds regarded as Muschelkalk. It needs but a glance at the camera sketch to convince those used to mountain profiles that at least nothing of the sort occurs up to the stream-bed between the Lower Trias and Muschelkalk, whilst

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[1] See Lydekker, *loc. cit.*, p. 125.

[2] Griesbach, *Mem. Geol. Surv. Ind.*, Vol. XXIII, p. 70, and Hayden, *Mem. Geol. Surv. Ind.*, Vol. XXXVI, p. 61.

the question as to whether a fault should be located there has already been disposed of in the negative.

## 5.—Weean Spur.

This spur descends in a south-westerly direction from the higher ridges and ends near the middle of the Vihi plain at the place marked Moonapoor on the Atlas sheet, Moonapoor however being a comparatively small town near the two larger ones named Weean.

At first, judging by the general strike of the Zéwan and lower horizons in the Trias at the Guryul ravine, one might expect to find them reappearing about this place were it not for the wrenching of the strike already indicated by the ridge (B) 6-8-08 and by the remnants of the Gangamopteris and Zéwan beds at Risin and Zéwan before they disappear under the fans and alluvium of the Vihi plain. That being understood, the limestones of the Weean spur, locally showing a N.N.E.—S.S.W. strike, clearly belong to the higher beds of the Supra-Kuling series of Lydekker as found much to the east of Khunmu in the section already described. I only spent an hour or two at this locality on my way to Mandakpal.

One poorly fossiliferous horizon (1) 14-8-08 was found in a slender band of limestone weathering a bright yellow colour. It contained *Spiriferina* cf. *Stracheyi*, and some other small brachiopods *Athyris* or *Dielasma* (?). It lies in a little ravine running S.S.W. to Weean and Moonapoor. East of this near Krew the same beds continue with a rolling dip, and east of Krew again the same in very well-bedded, bare masses, but not examined by me.

As originally described by Verchère (*Journ. As. Soc., Bengal*, Vol. XXXV, pt. 2, p. 169), the Weean beds yielded a large and varied assortment of forms (see list given by Diener, *Pal. Ind.*, Ser. XV, Vol. 1, pt. 2, p. 7); although it is true Diener discountenanced the most of these determinations, which were founded on very poor, broken material.

Nevertheless, it seems likely that somewhere in the neighbourhood of Weean exposures do occur yielding a large number of fossil forms. My own notes above made *en route* add nothing to our knowledge of the fauna, rather the reverse, but they are reproduced because of the structural evidence therein contained that these rocks really are of somewhat higher horizon than those in

the Guryul ravine. Their future thorough examination together with that of all the higher great limestones of Lydekker's Supra-Kuling series is a desideratum.

## 6.—Mandakpal Section.

Mandakpal consists of two small hamlets south of the large town of Shar. One of these is about the place of the village so marked on the Atlas of India sheet, the other a little way up the ravine above the former and distinguished by a group of poplar and other trees. Though camping room is scarce, the upper village is conveniently situated for examining the sections.

Oldham and Hayden in their papers both refer briefly to Mandakpal, the latter identifying there *Spirifer Rajah*, Salt., and *Marginifera Himalayensis*, Dien., and generally stating that the section from the base of the Zéwan stage is similar to the Guryul ravine section. He also found traces of Trias cephalopods.[1] Verchère in describing the section as being the only one where Weean beds rest immediately on volcanic rocks made a serious mistake (*Journ. As. Soc., Bengal*, XXXV, pt. 2, p. 172).

In many respects this southern side of the Vihi plain bears a strong physical resemblance to the northern or Khunmu side. The Carbon-Trias rocks lie above the Panjal volcanics and form side-spurs from the main ridge which runs N. by E. from Wastarwan peak. Although poorly exposed on the main ridge and higher side spurs where there is much forest, they are well seen on the spur above upper Mandakpal, from which, at or near the level of the Vihi plain, their strike bends round rapidly towards the west, south-west and south so as to catch the lower ends of the Loodoo and Barus (Barsu) spurs where they descend to that plain (see Pl. 31), a position very similar to that on the north or Khunmu side where they catch the lower ends of the Risin and Zéwan spurs. The camera sketch and section (Pl. 32) will indicate the general series and the fossiliferous horizons there exposed up to the Lower Trias near the top of the spur.

As in the Guryul ravine, the lowest beds immediately overlying the trap are not visible at the mouth of this ravine, but only

[1] Probably Godwin-Austen's section marked as near Loodoo is a combination of this section with that of the next spur (*Quart. Journ. Geol. Soc.*, Vol. XXII, p. 35).

appear much higher up its bed above the little tree- and crop-covered alluvial flat which forms the upper hamlet; the first beds identifiable on the way to this hamlet from lower Mandakpal being as high in the series as the *Spirifer Rajah* zone (2) 14-8-08. I shall therefore begin the description of the section of this spur at a point in the bed of the ravine ½ mile above the upper hamlet carrying it as far as the *Spirifer Rajah* bed, after which the section will be continued as exposed up the slopes immediately N.E. of the hamlet.

Superficially the section along this spur differs from that in the Guryul ravine by the profile not being split up by prominent crags: nevertheless rudimentary traces of such can be detected along certain portions of the slope.

*Novaculite.*—The novaculite bed is about 6 feet thick lying directly on soft volcanic ashy beds, very splintery. There are no traces of any siliceous shales or carbonaceous shales with *Gangamopteris* as at Risin and as partly seen in the Guryul ravine.

*Massive, clear grey Limestone.*—This follows directly on the novaculite, is about 60 feet thick and contains crinoid stems in places.

*Protoretepora beds and* (1) (2) 16-8-08.—The *Protoretepora* zone follows immediately, consisting of 20 to 30 feet of dark shale and interbedded thin limestones crowded with *Protoretepora ampla* and a few crinoids.

Just at the top of these beds comes a 2 feet thick layer of flaggy limestone underlain by a thin band of shale. The former weathers out into an inclined floor or shelf and affords the natural pathway along and up the slope. Both are fossiliferous (1) 16-8-08 in the limestone being the richer. From (2) 16-8-08 in the shales were obtained a few examples of *Productus semireticulatus*, lying alone in one thin bed. From (1) 16-8-08 were obtained a large number of *Productus* cf. *Gangeticus* or cf. *Purdoni*, *P.* cf. *cancrini*, and *Productus* sp., also large numbers of *Marginifera*, distinct from the species referred to as cf. *Himalayensis* and perhaps nearer to *typica*, Waag., together with a few *Dielasma* cf. *acutangulum*, Waag.

*Dark sandy Shales and* (2) 14-8-08.—As in the Guryul ravine section there now follows a good thickness of dark sandy micaceous shales, setting in at first by gradual interbedding with calcareous layers.

After 140 feet of these we reach along this line of section a thin bed 1 to 2 feet thick rich in rather well-preserved specimens of *Spirifer Rajah*, but apparently containing nothing else. On the slopes just above the upper hamlet, however, several other brachiopods are associated in what appears to be the same bed; whilst in the interval between the two exposures but at a point rather lower than one would expect, the same bed by faulting, or a slightly lower one elsewhere not found, becomes much thicker and very rich in fossils. Owing to covered ground intervening it was impossible to connect the three exposures by a continuous outcrop. The middle one just referred to is situated just beyond where the upper end of the fields on the alluvial flat come to an end and where the last of the poplars is seen. It is about 4 feet thick and yielded most of the forms enumerated below which combine the collection from all three exposures:—*Spirifer Rajah*, very numerous, some well-preserved specimens showing both valves, *Spirifer* cf. *fasciger* (*musakhelensis*), rare, only a few specimens found; *Marginifera himalayensis* also very numerous, and generally just below the *Spirifer Rajah* layer; *Productus cora*, d'Orb., also numerous and well-preserved; *P.* cf. *Abichi*, several; *Camarophoria* cf. *Purdoni*, 2 specimens only; *Dielasma LaTouchei*, Dien., 2 specimens; *Derbyia* sp.: *Aviculopecten* cf. *hiemalis*; *Lyttonia*, and *Amplexus* sp. (?).

Above this bed in the general section the sandy shales continue for 360 feet more up the slope, but with a few thin limestone beds appearing, which near the top become more numerous until they pass up into the limestones with shaley partings (Lower Trias).

*Lower Trias, Fossil Horizons* (3) *and* (4) 14-8-08.—As was found to be the case east of the Guryul ravine, the limestone beds identified with the Lower Trias, are not marked by any lithological change. They are simply horizons in a series gradually becoming more purely calcareous, and distinguished by containing fossils. The fauna resembles that of (1)—(4) 6-8-08 in the section east of the Guryul ravine, but the specimens are more fragmentary. Among the forms present the genera *Pseudomonotis*, *Meekoceras* and *Danubites* were rather doubtfully recognised. The association of forms and the general position of the bed being so similar to that of the Meekoceras horizon of the Lower Trias east of the Guryul ravine, I have no hesitation in classing it with the Lower

Trias. These are doubtless the cephalopods referred to as *Goniatites* by both Godwin-Austen and Verchère (*loc. cit., ante*).

The bands can be traced for a short distance E.S.E. running somewhat diagonally towards the crest of the ridge, after which their continuation was not traceable owing to the complication of dip-slopes and stream beds with soil and jungle. In the other direction towards Shar the continuation of the same was doubtfully recognised as it descends and becomes hidden by the deposits of the plains.

Above these two fossil horizons the higher part of the spur exhibits about another hundred feet of similar but unproductive limestones, rather thin-bedded and with a 20 to 30 feet bed of sandy shale not far below the culminating crags.

*Above Lower Trias.*—No higher horizons were found on this spur, as at this position it presents a dip-slope down to the surface deposits of a side valley running W.N.W.—E.S.E. Higher beds do, however, occur on the main ridge from Wastarwan peak which runs in a N. by E. direction, but these were only briefly examined along the bridle track crossing a little pass in the ridge along the route from Shar to the Patarkool valley. An occasional fossil band was found, the equivalents of those in the thick limestones coming above the Muschelkalk E. of Guryul ravine. A good deal of these massive limestone beds, which are of a clear blue-grey colour with orange or chrome tinted blotches, exactly reproduce the appearance of the Hazara Trias.

Although there are no good sections on the pass and ridges near, the slopes being too much soil, and forest covered, it is possible that the chief Carbon-Trias horizons could be tracked out. That they also pass down across the pass to the Patarkool valley, along the boundary as marked by Lydekker seems certain. Near Gadpura, as seen from a distance, the somewhat bare slopes in the continuation of these rocks make it probable also that sections worth searching for fossils would there be found, as also higher up the Patarko valley in the direction of Prongam, whence came many of the type specimens described by Diener. I regret that I was unable to include this valley in my field programme.

## 7.—Spur S.W. of Lower Mandakpal.

This spur runs N.W.—S.E. from the main ridge north of Wastarwan, and the extreme N.W. end of it between Lower Mandakpal

and Loodoo (but nearer the former) has intercepted the lower Zéwan beds owing to the wrenching of the strike towards the west.

The beds comprise the grey limestone lying immediately above the Panjal volcanics and the Protoretepora shales. No novaculite nor Gondwanas were found beneath, and nothing higher than the Protoretepora shales, which compose an undulating dip-slope for the extreme end of the spur as it dips under the valley deposits.

With reference to the bending of the strike towards the west here indicated, it does not do so in a uniform curve but by gentle foldings—a sort of secondary plication (possibly combined with slight faulting) following the axis of the ridge. Thus viewing it from the west on the pathway to Loodoo it appears as in the sketch (fig. 2).

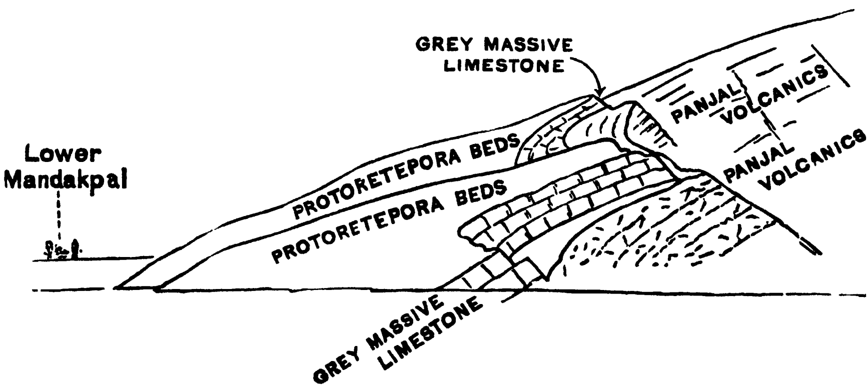


FIG. 2.—Spur S.W. of Lower Mandakpal.

## 8.—Ludu Spur.

The next spur in this direction, which also intercepts part of the Zéwan series descends to the plains at Ludu (Loodoo) village (not marked on the Atlas of India sheet, but situated about 1 mile S.E. from Goondlat). Here also the Protoretepora beds are first seen covering the slope of the spur towards the village, *i.e.*, dipping 30° N. As this exposure is about due west of the last spur described it does not require any change of strike, or very little, across the intervening space.

On the west side of this spur, however, a few hundred yards away, the strike curves round again once more and the beds dip N.W. by W.

Between the Loodoo spur and the next one running out to the isolated hill in the plain (shown in the Atlas sheet) there is a great shallow bay, and the Protoretepora beds and the limestone below in a confused way sheet the slopes for some way. Gradually the novaculite below shows up in blocks and then in masses as we get further into the bay and is followed by the Panjal volcanics. But there is no good section here, and the rugged slopes have probably portions of one or other or all of these beds adhering to the surface in places.

## 9.—Spur 2 miles N. of Barus.

The next spur runs west from the Wastarwan mass of volcanics, and as it dies away into the plain it is followed by the isolated hill referred to in the last paragraph. This spur shows a more complete section, and, together with the isolated hill, carries one presumably well up into the higher Trias limestones. No cephalopod horizons in the Trias were found, however, probably owing to their being hidden by covered ground near the foot of the spur (see Pl. 33, fig. 1).

Neither Oldham nor Hayden redescribed either this spur or the one at Barus itself, so that previous references are confined to the original workers in this area, Godwin-Austen and Verchère. The former gives a section of this spur in considerable detail (*loc. cit.*, p. 31) although he obtained no fossils above the *Spirifer Rajah* zone. The isolated hill is referred to by Verchère (*loc. cit.*, p. 172) as the "Pampur knoll," but his description of the section is far less accurate than that of Godwin-Austen.

*Novaculite (traces), Black Shales* (6 *ft.*), *and Grey Limestone* (60 *ft.*). —These three beds appear above the volcanics sheeting the lower end of the spur, the grey limestone being obviously the same as that with crinoids seen in the sections just described as far as Mandakpal.

*Protoretepora Shales and interbedded Limestone* (20—30 *ft.*).—The Grey Limestone passes up into the Protoretepora shales and thin-bedded limestones (1) 27-8-08, there being more limestones than shales at this point. *Lyttonia* was found in them.

*Dark sandy, micaceous Shales* (100 *ft.*).—The usual dark sandy micaceous shales follow here for about 100 feet.

*Spirifer Rajah and Marginifera bed*, (5) 26-8-08.—This fossil horizon is obviously identical with the horizon at Mandakpal containing the same species. Though equally rich in the two leading forms, which yield a bed 4 to 5 ft. thick, the only other species obtained were as isolated or very rare specimens of *Lyttonia*, *Productus* cf. *Abichi*, *Spirifer* cf. *fasciger* and *Amplexus*. The exact locality is just to the east, or mountain side, of the most marked gap in the spur.

*Dark sandy micaceous Shales with a few Limestones* (140 *ft.*).—These follow, the limestones very gradually increasing in strength. A small fault may interrupt the section near the gap.

*Spirifer Rajah* (*alone*) *zone*.—This is found a little below the crest of the next and most prominent point of the spur. I was at first disposed to regard this as a faulted representative of the previous zone, just as at Mandakpal I assumed the occurrence of (2) 14-8-08 as represented in the camera sketch on the sky line of the spur to be the same as the nearer exposure just beyond the fields of upper Mandakpal, the latter having been displaced downwards by a small fault. But it is quite possible that there are two separate beds in both places, the upper one being characterised by containing *Spirifer Rajah* alone.

*Sandy Shales as before with more numerous Limestones* (150 *ft.*).—These form the prominent point of the ridge and extend some way down the west slope, showing a gradual incoming in more strength of the calcareous element.

*Brachiopod and Lamellibranch beds*, (4), (3½) *and* (3) 26-8-08.—These appear unostentatiously in the section and form no feature at the surface. The productive layers are therefore difficult to detect, but they contain a rich and interesting little fauna. Horizon (4) contains *Pseudomonotis* and *Productus semireticulatus*; horizon (3½) is about 5 ft. above (4) and is characterised by pockets of matted-together, tiny lamellibranchs, *e.g.*, *Aviculopecten*, *Cardinia* and *Schizodus*, numerous small species of *Chonetes* and a few scattered examples of larger forms, *e.g.*, *Productus semireticulatus*, *P.* cf. *Gangeticus*, *P. Cora*, and one or two of *Xenaspis carbonaria* Waag (?). Horizon (3) is 20 ft. above the last and contains matted-together lamellibranchs similar to the last but not so well preserved.

*Shales and interbedded Limestones and dark Shale band* (100 *ft.*).—These resemble what have gone before, but the dark shale band in

the next saddle may well represent (2) 9-8-08 in the Guryul ravine section.

*Thin-bedded dark qrey and yellowish mottled and banded Limestones* (350 *ft. and over*).—The abovenamed continue down the slope to the west and become lost under the alluvium, to reappear again some distance away in a small exposure among the alluvium. No fossils. I correlate these with the crags foıming the higher part of the Mandakpal section and those of the Guryul ravine section which comprise within them the Lower and possibly Middle Trias.

All the beds in the above section dip at angles increasing from 30°, near the Panjal volcanics, up to 50°, which is the normal dip.

*Limestones, etc., of the Isolated Hill* (1,000 *ft. about*).—What appears to be a normal continuation of the same section just described is provided by the isolated hill already alluded to. At its eastern foot there are some few sandy shales badly exposed, followed by a continuous section through the hill of rather clear, blue-grey limestone, often mottled or blotched with chrome-coloured patches or splashes (2) 27-8-08. These may represent any of the beds which succeed in ascending order above the Middle Trias of the Guryul ravine, and which are also found in the pass east of Mandakpal.

Their resemblance to the Triassic limestone of Hazara is very complete.

They keep about the same dip and vanish under the wide plain to the west. Godwin-Austen has introduced in his section of this hill a fold which I did not observe.

## 10.—Barus Section.

The village of Barus is not marked on the Atlas of India sheet, but it lies in a little stream-bed surrounded by banks of alluvium at a point E. or E. by N. of Goorpoor on the Jhelum. There are no exposures actually at the village, but rock occurs a few hundred yards to the south of it in the spurs descending irregularly west from Wastarwan and which are partially buried in alluvium. Both Godwin-Austen and Verchère included this spur in their accounts, and from it came many of the fossils described by Diener. The section on this spur (Pl. 33, fig. 2) is remarkable for showing a limestone band, (1) 25-8-08, with obscure traces of fossils interbedded

with the Panjal volcanics at a horizon 100 to 200 ft. below the uppermost trap beds. It is from 10 to 20 ft. thick, of a dark colour and associated with some quartzitic and shaley material. It conforms in dip to the rest of the section, namely, 40° W. by S.

Above the trap the lower beds of the Zéwan stage are developed rather more strongly than in the last described sections on this side of the Vihi plain. The limestone and novaculite layers at the bottom are much mixed. They are followed by 28 ft. of cherty shales. Fossil horizon (1) 24-8-08 in grey limestone is full of examples of a *Productus* of the *lineati* group, which are mostly compacted into the rock and cannot be extracted, whilst many are spoilt by calcite veins. Both it and the next fossil bed must be lower than anything in the Mandakpal section.

The flaggy limestone (2) 24-8-08 which overlooks a small quarry shows a face of rock covered with a small Productus of (?) nov. sp. Bed (3) 24-8-08 contains crinoid stems.

The *Protoretepora* bed though rather poorly exposed is identified with ease, and so is the *Spirifer Rajah* bed, (1) 23-8-08, which can be traced for a long distance up the hill side by its very characteristic large shells. The dark sandy and micaceous shales also contain imperfectly preserved fossils here and there through their thickness.

## 11.—Previous Horizons compared and chronologically arranged.

In order to get a comparative view of the sections so far described, namely, those of the Golabgarh Pass and Vihi district, I have drawn a few parallel vertical representations of them, one for each of the five main localities (Pl. 34). In these are exhibited the rock and fossil succession upwards and downwards from the *Protoretepora ampla* zone, which is taken as a datum line to reckon from because, being common to all the localities, it is probable that it was contemporaneous in them all.

The three sections on the right are sufficiently self-explanatory, but the Barus section and that of the Golabgarh Pass present some peculiarities. In the former there seems to be no doubt that the two fossil horizons, (1) and (2) 24-8-08, are older than anything appearing in the sections to the right. In the Golabgarh section the difficulty is to know at what point to introduce the grey limestone equivalent. Assuming that, in the Barus section, the cherty

shales coming above the novaculite, etc. (which in the Zéwan section have yielded *Gangamopteris*) are the equivalents of V and W.-1 horizons of the Golabgarh Pass, we are still left in doubt as to whether the grey limestone should range above or below the bed with *Glossopteris*. On the whole it seems more probable that its horizon approaches that of Z.-1 and so ranges above that upper plant bed of the Golabgarh Pass section.

In the following list I have grouped in descending order all the fossil horizons extracted from the several vertical sections, arranging them in their absolute order of succession as indicated by those sections. Where two or more appear in one line they are supposed to be of identical age so far as determinable :—

*Fossil Horizons of Golabgarh Pass and Vihi Sections.*

| | |
|---|---|
| (1) 14-8-08 { (4) 8-8-08<br>(3) 8-8-08<br>(2) 8-8-08<br>(1) 8-8-08 } | Probably Upper Trias. |
| near (7) 11-8-08<br>(7) 11-8-08<br>(6) 11-8-08 | Muschelkalk (?). |
| (3) (4) 14-8-08, (1) (2) (3) (4) 6-8-08 | *Meekoceras* beds. |
| (3) 26-8-08<br>(3½) 26-8-08<br>(4) 26-8-08 | |
| C, (1) 23-8-08, (2) 14-8-08 in part<br>B, (5) 26-8-08, (2) 14-8-08 | *Spirifer Rajah* and *Marginifera* beds. |
| (1) 9-8-08, (1) 7-8-08<br>(1) (2) 16-8-08, (1) 2-8-08 | |
| *Protoretepora* beds throughout. | |
| Z-1, (1) 4-8-08 | |
| (3) 24-8-08<br>(2) 24-8-08<br>(1) 24-8-08 | |
| X | *Glossopteris* bed. |
| W-1 | *Gangamopteris* bed. |

## V.—LIDAR VALLEY SECTIONS.

### 1.—Eishmakám.

In the Lidar valley, one march above Islamabad, lies the little town and monastery of Eishmakám, perched on the lower slopes of one of the secondary hill-spurs which splay out westwards from the S.W. spur of Lewapatoor Station (13,012 ft.) and cause a partial contraction of the Lidar valley at this point.

This is the first of several localities up this valley where rocks of Lydekker's Kuling series have been described by that author as lying in a series of tightly packed isoclines among the Panjal series with reversed dips to the N.N.E. in the direction of Pailgam.[1] The locality is also one from near which several species of brachiopods and other fossils collected by Lydekker have been described in Diener's memoir (*Pal. Ind. Him. Fossils*, Ser. XV, Vol. I, pt. 2).

For these reasons I proceeded there to make a further collection of specimens from them, and to study their relations to the apparently underlying and overlying Panjal series, which, according to Lydekker, has enfolded them in this isoclinal way.

On the up-journey to this place and Pailgam my explorations were much interfered with by rain, but on the return trip I was able to visit them again. Owing, however, to the exigencies of the routes up and down this valley, and to the way the continuous sequence of beds is interfered with by alluvium and by the alternate approach and recession of the side-spurs to and from the line of march, it was impossible, without stopping on the way, to perfectly co-ordinate the observations at one place with those at another. The poorness of the topography of the old ¼-inch map was also a great handicap in such work. The following notes give a sketch of results attained by me in this neighbourhood.

The general run of the lowermost subsidiary spurs immediately behind and north of Eishmakám, together with the lie of the rocks and the position of certain fossil horizons will be apparent from the

[1] *Mem. Geol. Surv. Ind.*, Vol. XXII, pp. 136-138.

sketch plan and view (figs. 3 and 4), and further details will be found in the section (Pl. 33, fig. 3). The main bridle-road up the valley to Pailgam skirts the base of the spurs to the left of the view and does not expose a very continuous section, owing to alluvium intervening.

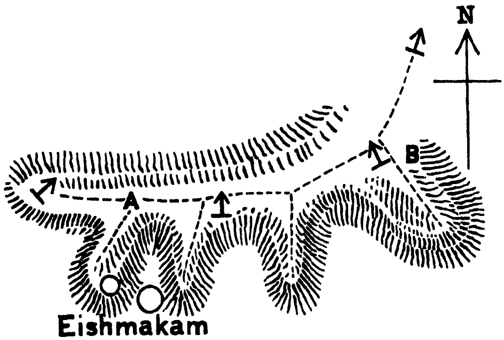


FIG. 3.—Plan of Eishmakám Hill.

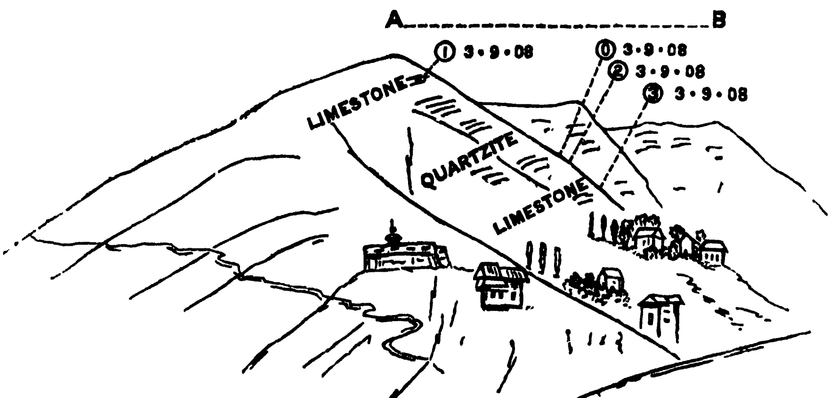


FIG. 4.—Profile view of Eishmakám Hill.

Higher up the slopes, however, another foot-track (shown in the sketch) exposes a fuller series, whilst still more perfect sections are disclosed on the rather steep slopes and the side spurs overlooking the town and extending beyond it to the east and north.

Almost a first acquaintance with these sections makes apparent a peculiarity of some importance in relation to the supposed parallel sections from the Vihi district, Gulabgarh Pass, Barus, etc., and those presently to be described near Pailgam—namely, that there are here at Eishmakám no *Protoretepora* beds, no *Spirifer Rajah* and *Marginifera himalayensis* zone, and no evidence of massive traps immediately below. There is also no novaculite and no dark sandy, micaceous shales. In fact, as already indicated in Prof. Diener's description of the fossils from near Eishmakám gathered by Lydekker, the facies of the fauna here is an entirely different one.[1] The rock facies also is dissimilar, for not only do the series of limestones begin by being superposed on a set of quartzites and schists, of white and pink colour, but other quartzites and schistose slates appear at higher horizons among the limestones whilst at least two bands of trap likewise appear in the section between the base and crest of the ridge, and lying above the main fossiliferous horizons from which collections were made by me.

It may further be remarked that as we follow the outcrops of these fossiliferous beds away from Eishmakám round the convex curve of the spur up the valley towards the north-east, they take a course of outcrop also convex towards the south-east, as if normally bedded below the trap and slates which appear to follow above them and proceed to form the mass of the higher peaks to the N. Also the outcrops do not show any sign of weakening or diminishing in thickness in this direction (as one might expect if they were involved in an isocline, as advocated by Lydekker).

The fossils themselves are not very well-preserved as a rule, nor easy of extraction, but from beds (O), (2) and (3) of 3-9-08 (fig. 4) and (3) and (4) of 5-9-08 (Pl. 33, fig. 3) I was fortunate enough to obtain a number of large brachiopods, which when brought to Calcutta were at once recognised by Mr. Hayden as *Syringothyris cuspidata*, Mart. Some of the specimens were even broken

[1] It seems more than doubtful, however, whether any of Lydekker's specimens came actually from this spot, though marked as near or north of Eishmakám. The rock with *Spirifer Lydekkeri*, *Phillipsia* and *Fenestellae*, as shown by Lydekker's specimens, is almost certain to have come from a place some few miles further north and lying about S.S.E. of Duwhat and Loor (see on p. 323). Lydekker's description of the locality for *Phillipsia* as 8 miles from Pailgam down the valley makes this clear, though his reference in a foot-note to Bhatkot as being near Kostu is unhappy, since the former is 7 miles N.N.E. of the latter.

across fortuitously so as to show perfectly the dental and transverse plates and the tubular process of that species, exactly as described with figures by Mr. Hayden in the Appendix to Prof. Diener's memoir (Permian Fossils of the Central Himalaya, *Pal. Ind.*, Series XV, Vol. I, pt. 5). Other fossils obtained from these beds are—from (O) 3-9-08 many *Productus lineatus*, Waag., a large type very like those from Spiti, an imperfect specimen of *P.* cf. *scabriculus*, Mart., a large *Chonetes* and several specimens of *Athyris* sp., and from (2) 3-9-08 a few of *Productus lineatus* and *Athyris* (?) *subtilita*, Hall, together with rock lumps full of well-preserved specimens of *Chonetes* (?) *hardrensis* var. *tibetensis* Salt.

As *Syringothyris cuspidata*, Mart., a typical Lower Carboniferous form from the Mountain Limestone, has also been found in the Spiti (Kanawar) sections of the Lipak R and elsewhere by Hayden at a horizon well below the Permian and Fenestella shales, and as the rest of the fauna is unlike the Zéwan fauna, it is scarcely possible to resist the conviction that we have here at Eishmakám something quite different from the Vihi, Gulabgarh Pass and other sections, and that Lower Carboniferous strata are really represented. It also seems to follow of necessity that we must revise our conception of these outcrops as being isoclines of younger rocks enfolded among the older Panjal slates and trap, and be prepared to recognise the whole section from here to Pailgam as possibly being a normal ascending one—a recognition which would of course assign to the so-called Panjal traps (which follow above and occupy the higher parts of the valley south of Pailgam and the summits of Lewapatoor Station) an age between Lower Carboniferous and Permian.

It should be mentioned here, however, that it is not quite certain that some of the trap beds are not intruded along the bedding, as there sometimes appears to be evidence for slight transgression across the edges of the associated limestones, etc., whilst one definite dyke, at least, is seen ½ mile N. of Eishmakám cutting vertically through the canal bank and bridle-road above. But, whether some of these bedlike masses are intrusive or not, the point is clear that, assuming the section a normal one, none of them can be older than Carboniferous, and there is abundant general evidence elsewhere that none can be younger than the Protoretepora shales and beds with *Marginifera himalayensis* and *Spirifer Rajah, i.e.*, about Permian.

## 2.—Kollur, Dowhat and Lur.

The sections and outcrops at the above places lie on the other side of the river and a little N.N.E. of the strike of the Eishmakám beds if continued diagonally across the valley. They were only examined cursorily during a day's march, and must correspond to beds which should appear about E.S.E. of Srelgam crossing the S.W. spur from Lewatapoor Station at a point about 4 miles N.E. of Eishmakám.

Beginning ½ mile N.E. of Wallarhama, the spur between that place and Kollur shows first quartzites and some dark shales and limestones, the shales (1) 13-9-08 having obscure plant impressions. The general dip is 20°—30° N.E. by N. Between Wallarhama and Kollur the series continues to be exposed in a set of low spurs jutting out into the plain, the quartzites becoming more prominent and interbanded with black, carbonaceous and sometimes sandy shales. Limestones do not continue and there are no fossils except the obscure plant impressions referred to above. Occasional beds of angular conglomerate, like the ordinary Panjal conglomerate, are met with.

Between Kollur and Dowhat the same series apparently continues, and some limestones again come in, but the section is interrupted by surface deposits in the valley between Kollur and Dowhat.

S.E. of Dowhat and Lur, but on the opposite (Eishmakám) side of the river, and a little north of a rough bridge, a little jungle-clad precipitous spur descending to the river bank shows a section some 150-200 ft. thick, dipping 50° N. by E. and composed of very black, carbonaceous shales characterised throughout by being full of *Fenestellae*. The lowest bed exposed, (1) 6-9-08, contains also numerous large specimens of *Productus* with very long marginal spines spreading out moustache-fashion (cf. *undatus*). Above this follows (4) 13-9-08, containing among other things a portion of a trilobite, (*Phillipsia*). A large thickness of shales very rich in fenestellae (3) 13-9-08, succeed, being particularly well exposed up a steep path leading along the side of a torrent bed. In these were found also *Protoretepora*, a few corals, *Strophalosia* sp. and a *Spirifer* cf. *triangularis*, Mart. In the more sandy layer of shales immediately above this and underlying a glassy quartzite (the top of the section)

are some large specimens of (?) *Dielasma*, *Productus* sp. and some fairly well preserved examples of *Spirifer* cf. *triangularis*.

Among these beds the universal presence of *Fenestellae*, the trilobite, and the forms identified as *Spirifer* cf. *triangularis*, *Strophalosia* sp. and *Productus* cf. *undatus*, mark it down as the locality near or north of Eishmakám whence the fossils described by Diener have been derived, a conclusion borne out by a comparison of Diener's type-specimens and containing rock, preserved in the Geological Survey collections, with those found by me. It is certain that this horizon is considerably higher than the one I have described close behind Eishmakám town, and I think it is almost equally certain that it is not the equivalent of the Protoretepora shales of other localities but probably a much lower horizon.

What follows immediately above this is not yet known in the above section, but again on the opposite (Loor) side of the valley to the N.E. of Loor, slates with angular conglomerate of Panjal type speedily set in, and then follows an enormous thickness of massive Panjal traps to beyond Ganesbal, which lies a little way below the junction of the west and east branches of the Lidar valley.

The whole of the section thus briefly sketched between Wallarhama and Loor would repay detailed examination on another occasion, inasmuch as, although Lydekker's theory of a set of repeated isoclinal folds of the shales, quartzites and limestones among an older Panjal slate series is still a not impossible way of reading the section, it has had very grave doubt cast on it by this discovery of a characteristic Lower Carboniferous fauna from the Eishmakám beds, which beds in all points possess a strong resemblance to those found in normal succession below the Permian in Spiti. That Mr. Hayden anticipated this reading of the section is seen from the following extracts from his Spiti memoir :—

"Judging from the manner in which the younger palæozoic beds thicken out again in Upper Spiti, it is probable that they will be found also to the north, in the valley of the Upper Chandra river in Lahaul and in Kashmir. In fact a great area has been mapped by Mr. Lydekker in that area as 'Panjal,' but from his descriptions of that system, it is possible that it may include a considerable part of the shale and quartzite series now known to be most probably of upper carboniferous age" (*Mem. Geol. Surv. Ind.*, Vol. XXXVI, pt. 1, p. 57).

Also again (p. 58) :—

"It seems possible, however, that lower carboniferous limestones may occur in Kashmir, for certain sections described by Lydekker, in which slates and quartzites are found over-lying limestones, distinctly recall the carboniferous beds of lower Spiti; in most cases, however, Lydekker looks upon the slates and quartzites as members of his Panjal system and consequently assumes that the section is inverted, and that the limestone belongs to his 'Supra-Kuling' series."

With reference to the above suggestions as to what is probably the true order of sequence up the Lidar valley, it must not be supposed that I am venturing (after a brief acquaintance only with the neighbourhood) to correct an elaborate piece of mapping by Mr. Lydekker. Detailed field-work, sufficiently close to produce such a result on the merits of individual sections, was naturally out of the question with the small-scale map then—and even now—available, and in the time that Lydekker could devote to any one part of Kashmir. His map and section of this part were therefore merely an "interpretation" of the structure according to the data then available. The modified reading of the section suggested by me is also only an interpretation in the main, though based on later work and fuller knowledge of neighbouring regions. I quite recognise that its final acceptance must wait until further field-work done on the spot with better maps (if possible) has proved it to hold good at each separate point over the area.

## 3.—Pailgam.

Near Pailgam, where the river bifurcates, the upper surface of the highly inclined, massive Panjal traps descends in steep dip-slopes to near the level of the river, and carries above it representatives of the Zéwan limestones and micaceous shales, which latter pass upwards, as in the Guryul, Mandakpal and other sections into Trias and higher beds.

But, unfortunately for close geological work in this locality, the two river courses run nearly along the Zéwan horizon for some distance, and thick alluvial gravel terraces cover everything below. On many of the lower slopes also a mantle of surface soil and dense pine forest similarly hides a large portion of the solid geology. The following fragmentary sections give the substance of my observations.

On the left bank of the east stream below Pailgam village the undulating ground used as a camping-ground for visitors leaves no rock exposed except in stray blocks. But at the N.W. extremity of the hill-spur N.E. of Pailgam and a little beyond the bridge above the town, the usual Permian dark sandy shales come down to the river's edge, dipping S.W. by W. at 30°. The rocks have been cleaved, and the fossil contents, chiefly *Productus semireticulatus*, have been considerably distorted and sometimes drawn out to two or three times their proper length (1) 8-9-08. The rock facies is typically like that of the Vihi district and quite unlike any of the exposures seen at Eishmakám and at intermediate places on the way to Pailgam. A continuation of these is found across the river, but exposures are very poor.

Up the west Lidar valley no characteristic exposures are found on the left bank until beyond Moondlan, when the same shales, with limestones above, appear as the whole series cross the river preparatory to a rapid change of strike. No fossils were found as far as examined by me up to one mile south of Aro, but on the right bank at a point about 2 miles N.W. of Pailgam and near the first bridge, there were found traces of fossils in roughly cleaved sandy shales. Nothing definite, however, was obtained except one little globose ammonite *Nannites* (?) (3) 10-9-08, and a rude shape suggestive of a *Productus* (4) 10-9-08.

Coming behind these beds in the vicinity of Mamal village we have ochre-coloured limestones with vague impressions of fossils. and some purple slates down to the Panjal traps. These beds are probably equivalents of the lower part of the Zéwan stage, but no fossils were found.

Traverses over the Supra-Kuling limestones which rise into the steep ridge lying in the fork of the two river branches showed nothing definite on account of poor sections and much soil and forest, but near the top of the zig-zag bridle road which climbs this spur from Pailgam on its S.E. side, there were beds with corals and crinoids, etc., appearing on weathered surfaces, also a grey shaley band, roughly cleaved and with black lumps here and there, some of which can be seen to be cephalopods by their sutures (O) 11-9-08. At another place on the lower part of this hill after descending to near Moondlan I found some nearly black sandy shales weathering into soft clay with lumps of harder stuff. In the associated harder sandy shales I got one portion of a large ammonite, *Gymnites* (?)

(1) 11-9-08, and lower down an *Athyris* sp. (2) 11-9-08. These rocks may be near (B) 6-8-08 of the Guryul ravine section, *i.e.*, Muschelkalk.

The country generally at this junction does not lend itself to ready examination owing to the causes I have enumerated before, and to the steep slopes deeply dissected by torrent beds. At the time of my visit also constant rain had converted all the tracks into quagmires, which together with the baffling forest made all traverses very arduous.

Nevertheless, sufficient was seen to point to the sections of Lydekker's Kuling and Supra-Kuling beds here being practically identical with those of the Carbon-Trias surrounding the Vihi plain, and essentially different from those already described at lower points on the Lidar.

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## LIST OF PLATES.



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## Woodcuts in Text.

# MISCELLANEOUS NOTES.

## Thermal Springs in the Rajmahal Hills.

Notice of the occurrence of a thermal spring, not hitherto recorded, has been received from Mr. A. S. Pereira, Manager of the Mahespur Court of Wards Estate, who states that the spring is situated in a Santhali village named Sidpur, in Pargana Sultanabad of the Sonthal Parganas, at about a mile to the south of the Police station of Pakuria, approximately in latitude 24° 30′ and longitude 87° 45′. There is said to be a continuous flow from the spring, the water of which is warm and strongly sulphurous and is employed by the Sonthals both for medical and agricultural purposes.

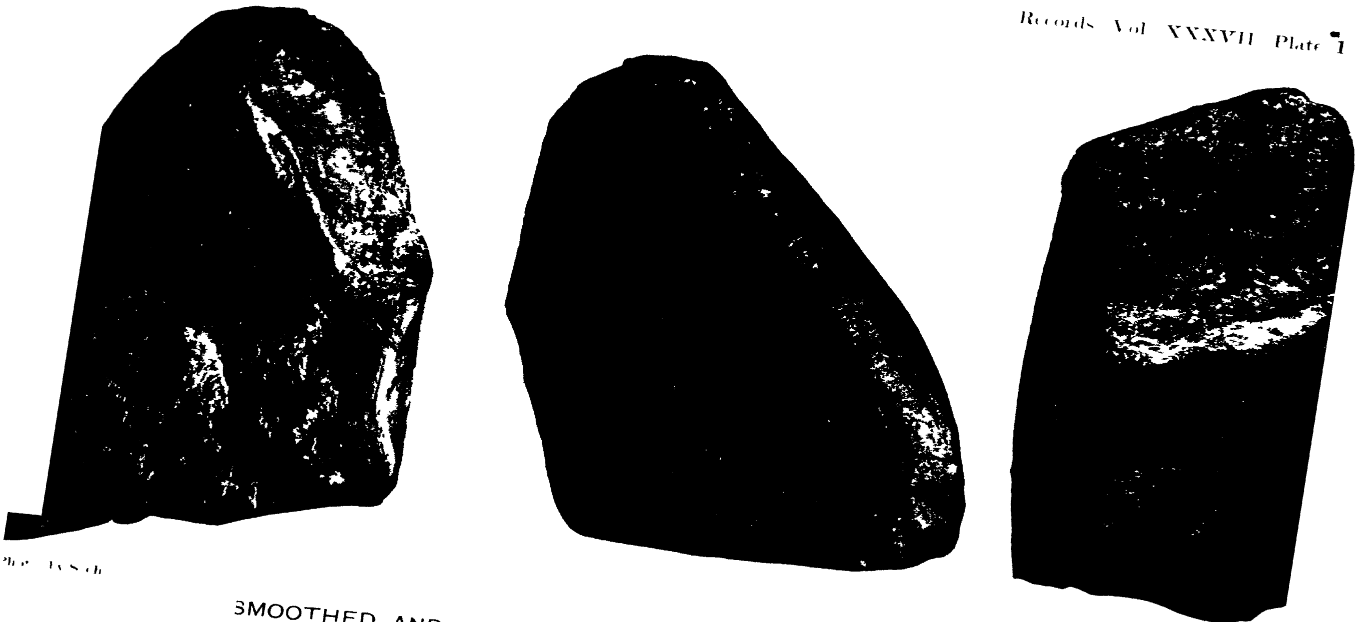
The occurrence of numerous springs in this area was recorded by the late Dr. V. Ball [*Mem.*, *G.S.I.*, XIII, 157 (1877)], but most of these were merely tepid. In the list of Thermal Springs of India, compiled by the late Dr. T. Oldham [*Mem.*, *G.S.I.*, XIX, pt. 2 (1882)], "a very copious outbreak of warm water" is said to occur at Jerwapani (?=Surwapani of Atlas sheet 113) near Gopikaudur (?=Gopikanoor). The Sidpur spring, now recorded, would lie at about 12 or 13 miles to the north-east of this spring.

[H. H. HAYDEN.]

# INDEX TO VOLUME XXXVII.



E



SMOOTHED AND STRIATED BOULDER, BLAINI STAGE, SIMLA.

*Half Natural Size*

[illegible] Calcutta [illegible]

**BUGTITHERIUM GRANDINCISIVUM**

*Upper Jaw (View from above).*

*Scale represents 12 inches.*

**BUGTITHERIUM GRANDINCISIVUM**

*Upper Jaw (View from below).*

*Scale represents 13 inches*

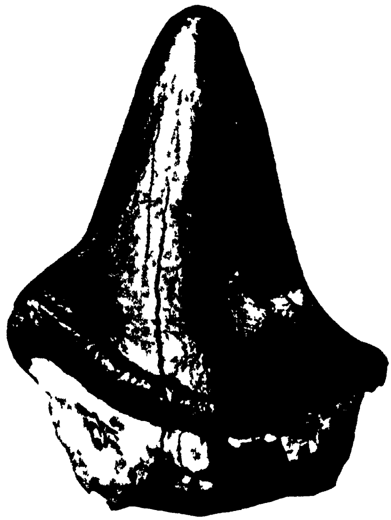


FIG 1

FIG 2

**FIG 1 BUGTITHERIUM GRANDINCISIVUM**

*2nd incisor (outer view)* × 1/1

**FIG 2. BUGTITHERIUM GRANDINCISIVUM**

*2nd incisor of another individual (inner view)*

*Natural size*

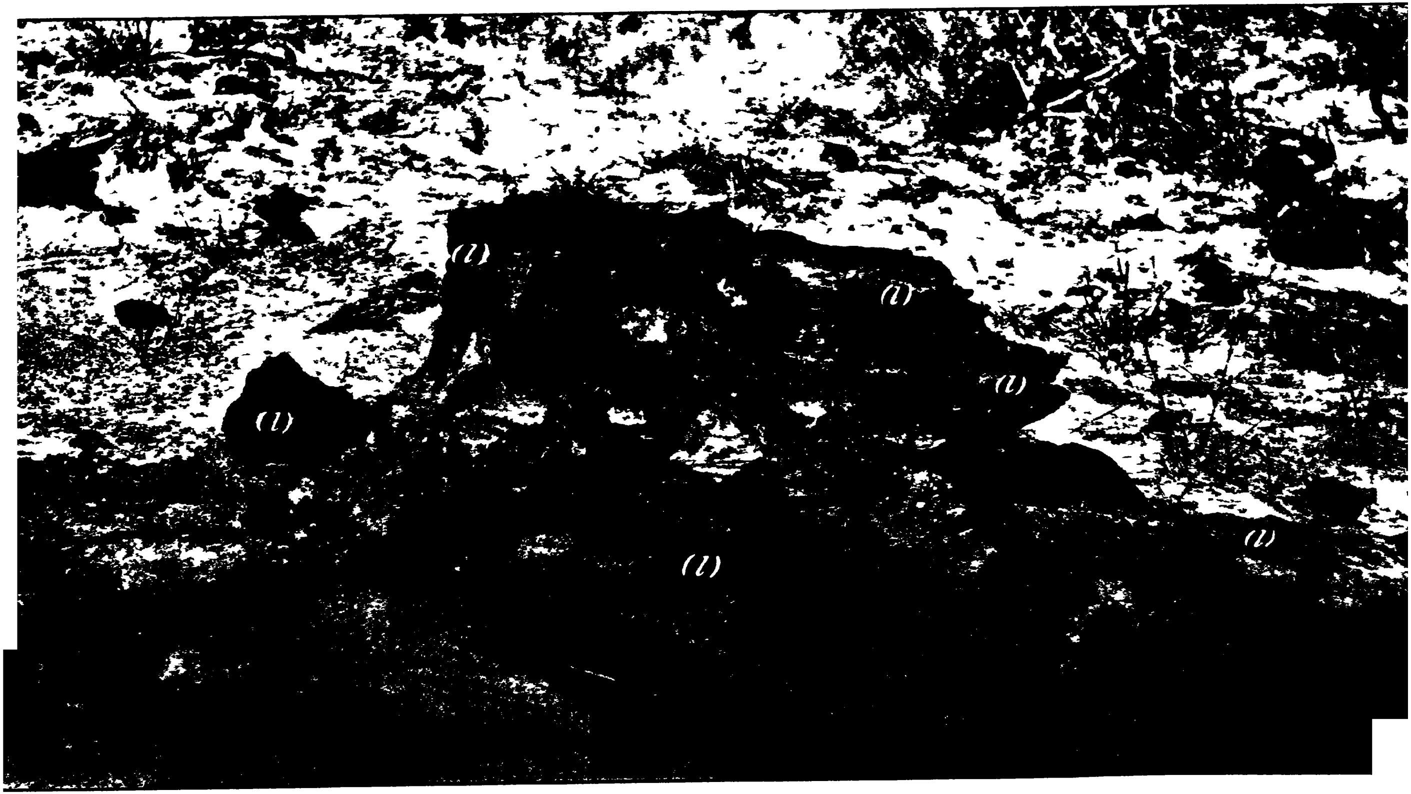
FALLS IN THE NARBADA RIVER AT MOKHADI

FIG 1

FIG 2

FIG 1. INCLUSIONS IN GLASS MADE FROM MANGAL HAT SAND. MAGNIFIED 25 TIMES.

FIG. 2. FOSSIL PLANT STEM PRESERVED IN HYDRATE OF IRON IN THE DAMUDA WHITE SANDSTONE, RAJMAHAL HILLS, $\frac{1}{2}$ NATURAL SIZE.




LAMELLAE OF FERRUGINOUS SEGREGATIONS (l) IN WHITE DAMUDA SANDSTONE SOUTH OF BORA GHAT

FIG 1

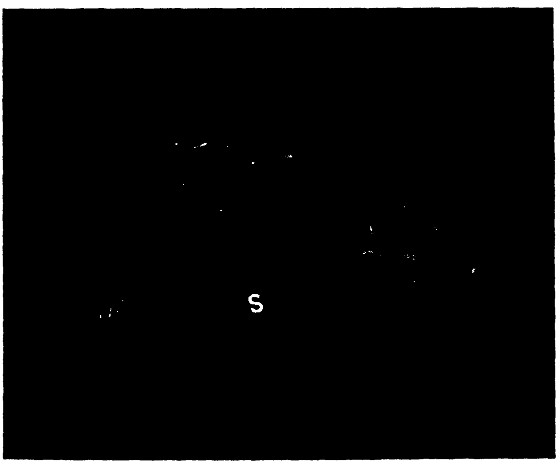
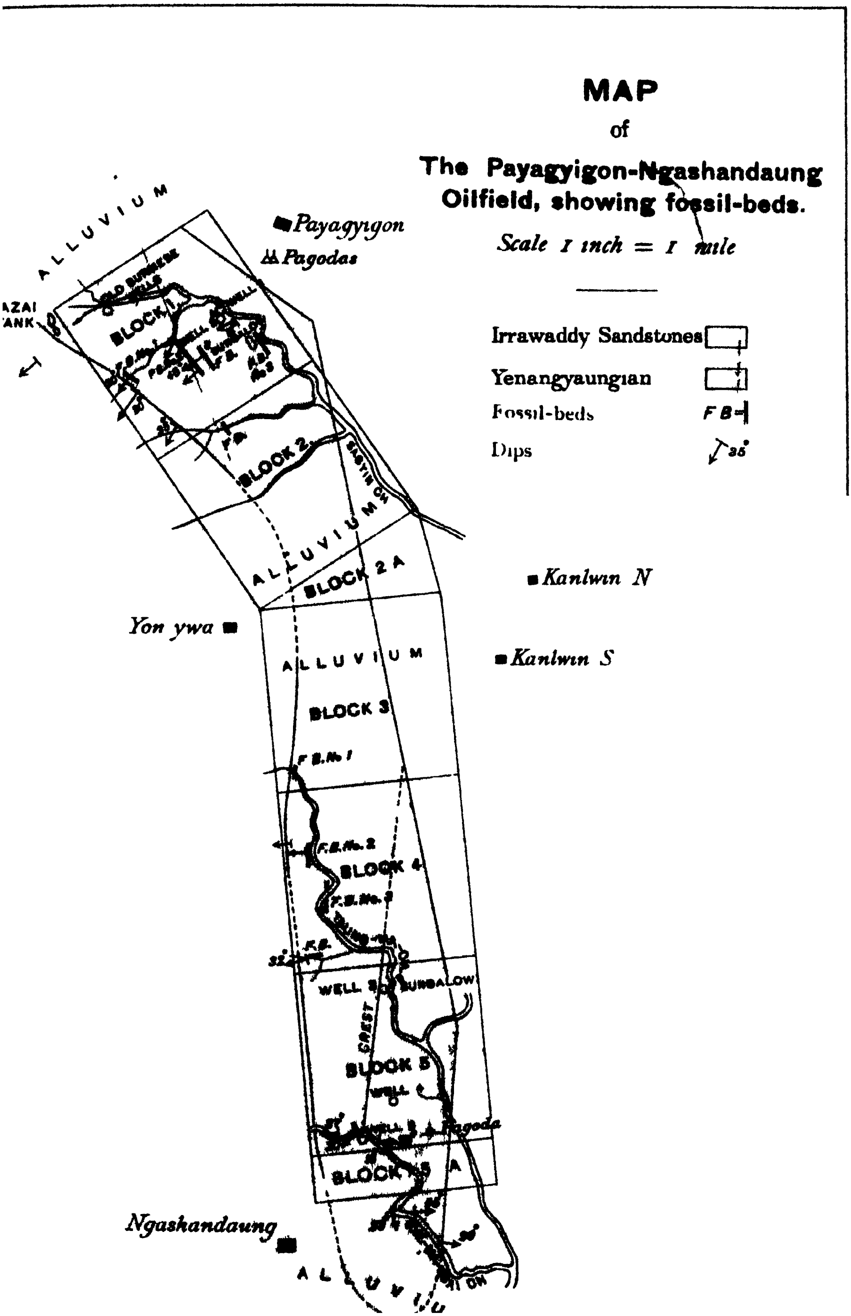
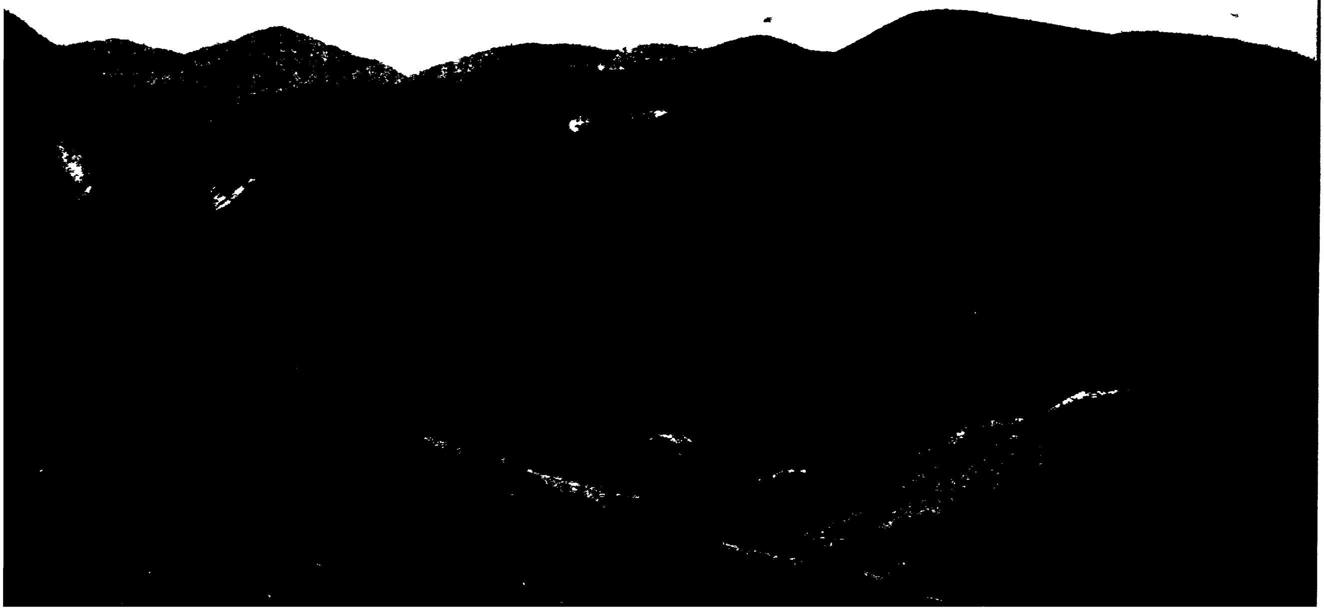



FIG 2

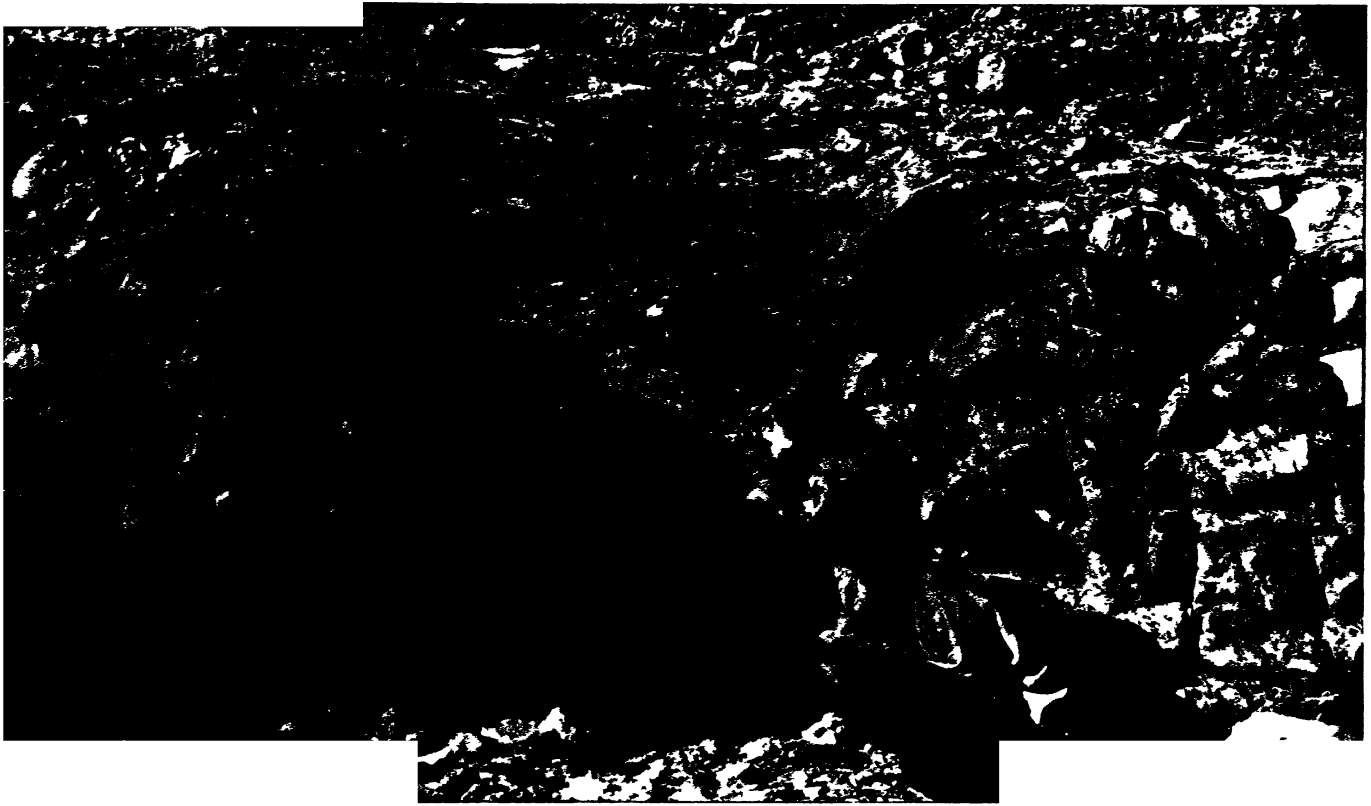
PORTION OF THE COLD-BOKKEVELD METEORITE WITH GROWTH OF ALUNOGEN (NATURAL SIZE), PORTION OF ORIGINAL SURFACE MARKED "S."


MAP
of
The Payagyigon-Ngashandaung Oilfield, showing fossil-beds.
*Scale 1 inch = 1 mile*
Irrawaddy Sandstones
Yenangyaungian
Fossil-beds
F B
Dips
35°
ALLUVIUM
Payagyigon
Pagodas
BLOCK 1
BLOCK 2
BLOCK 2 A
BLOCK 3
BLOCK 4
BLOCK 5
BLOCK 5 A
Kanlwin N
Kanlwin S
Yon ywa
F.B. No. 1
F.B. No. 2
WELL
BUNGALOW
CREST
Pagoda
Ngashandaung

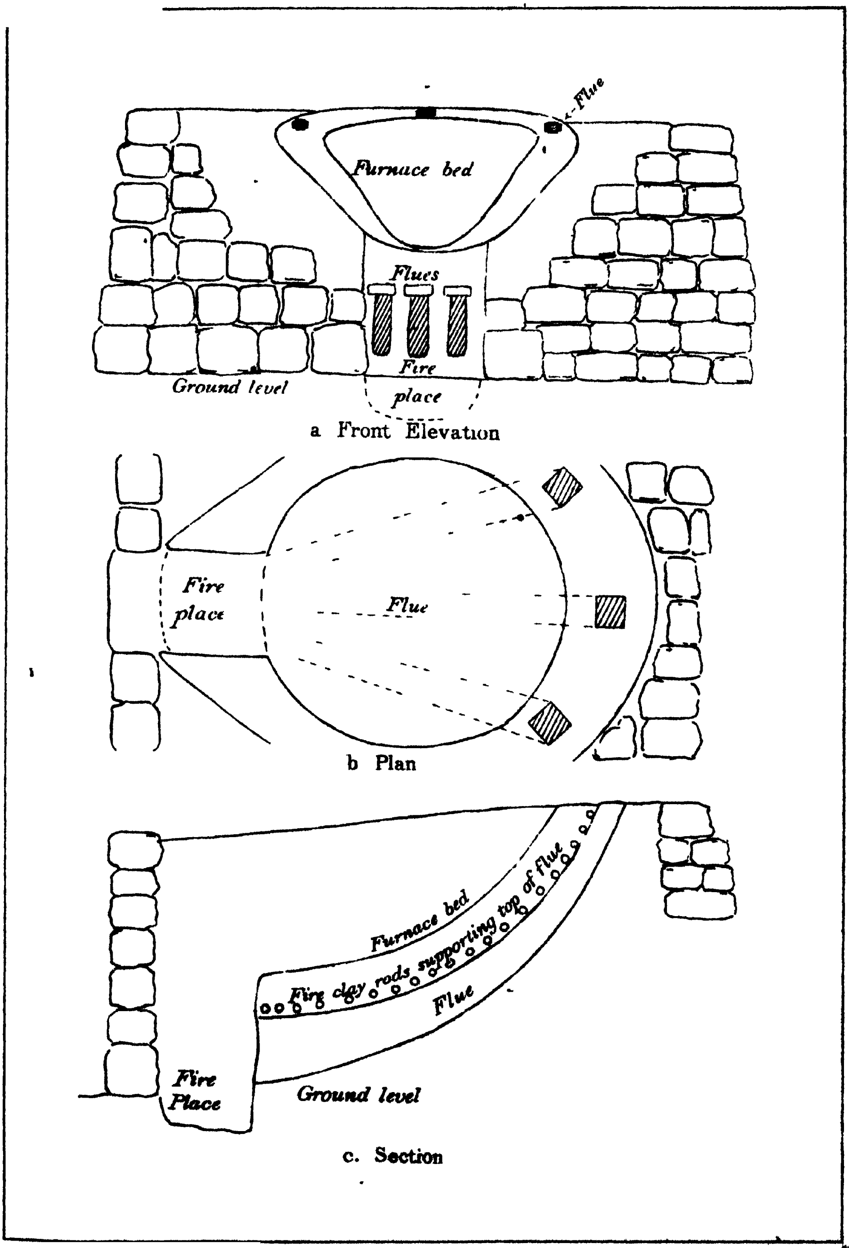


BAWDWIN, GENERAL VIEW SHOWING SLAG HEAPS IN FOREGROUND.

THE AMPHITHEATRE, BAWDWIN.

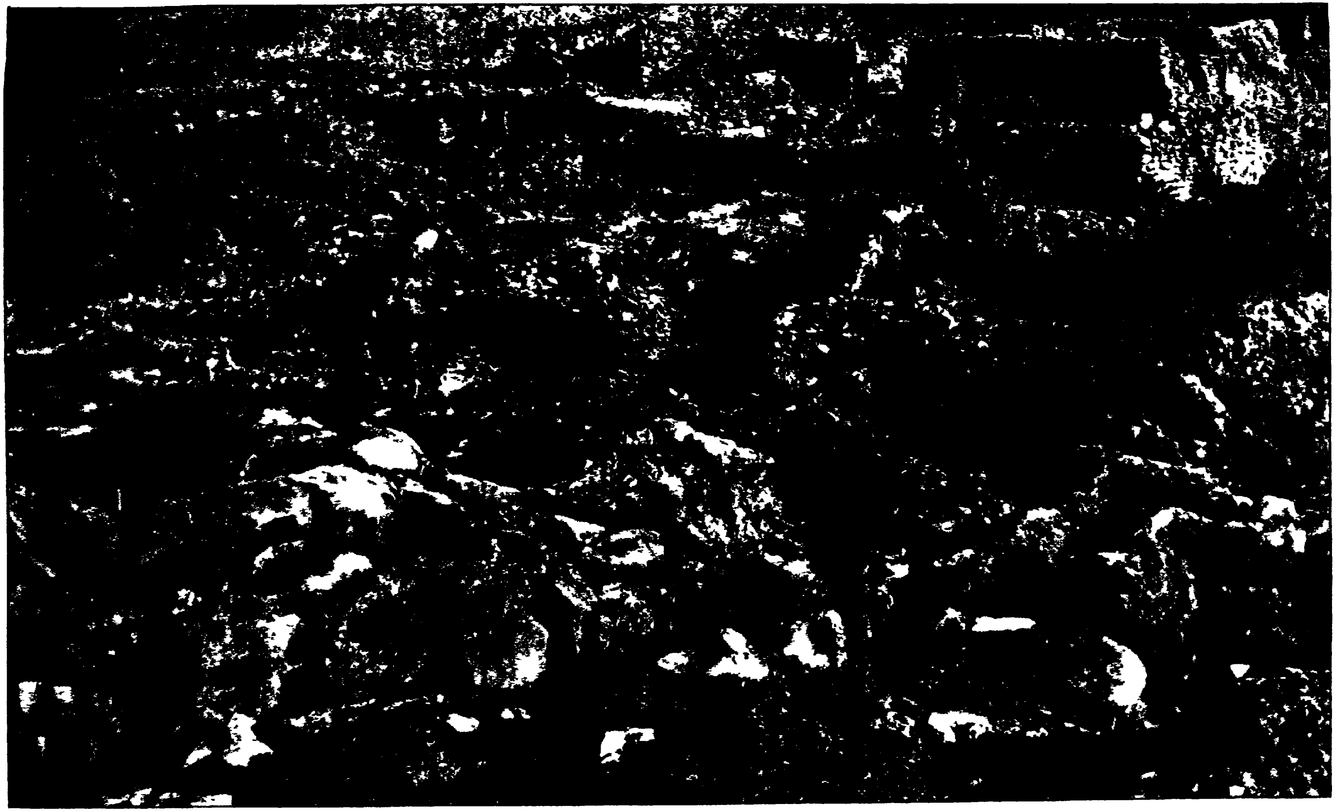


CHINESE SMELTING FURNACE, BAWDWIN

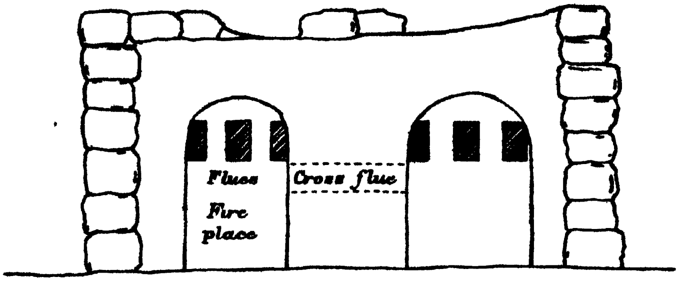



LARGE SMELTING FURNACE

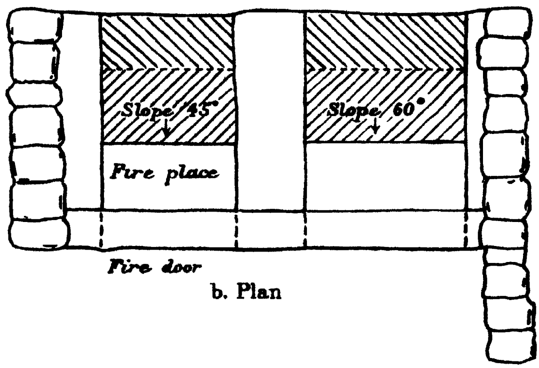
*1 inch = 4 feet.*



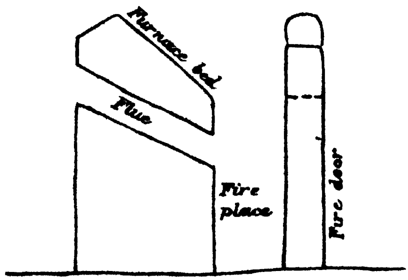
KACHIN SMELTING FURNACES AND REMAINS OF CHINESE HUTS, BAWDWIN.




a. Front Elevation



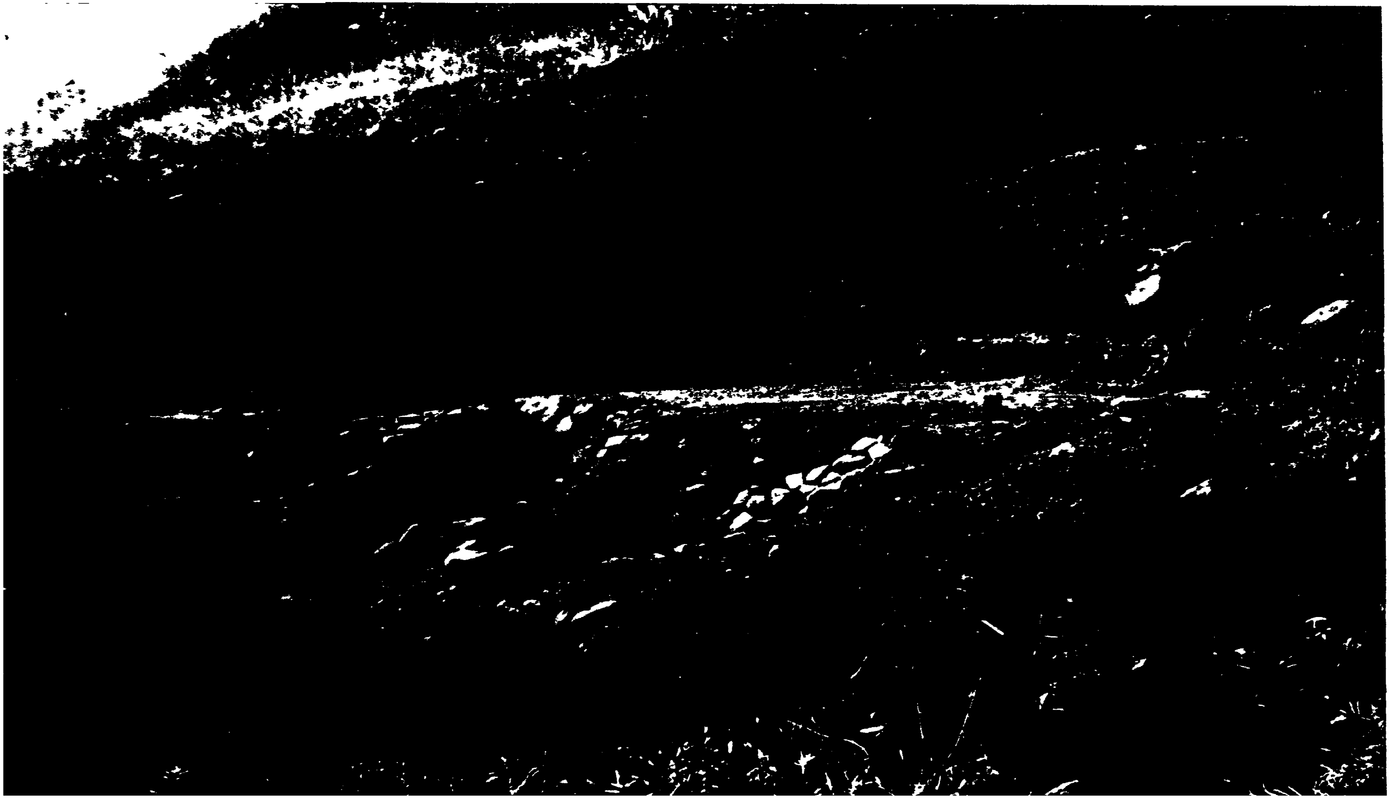

b. Plan



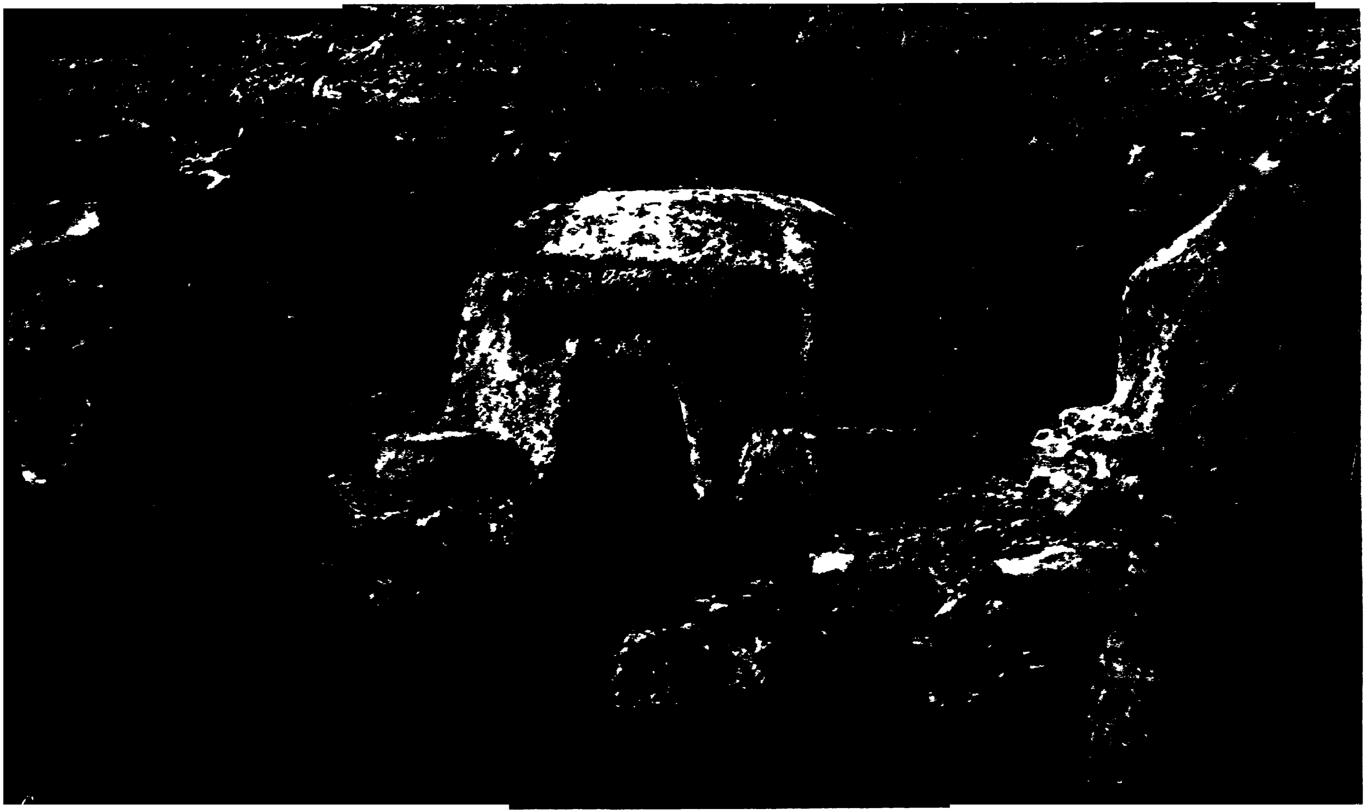

c. Section

**SMALL SMELTING FUR**

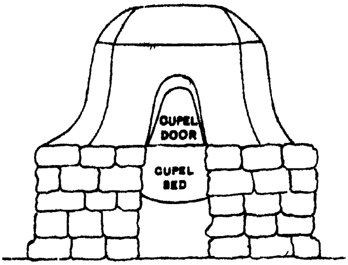
*1 inch = 2 feet.*



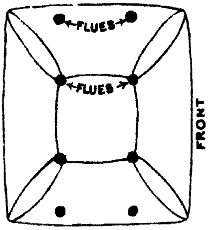
ORE DRESSING FLOORS, BAWDWIN.



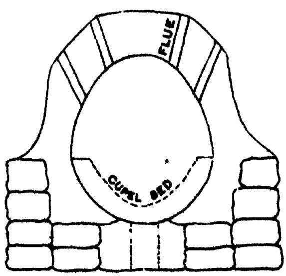
INESE CUPEL FURNACE BAWDWIN.




a. Front Elevation



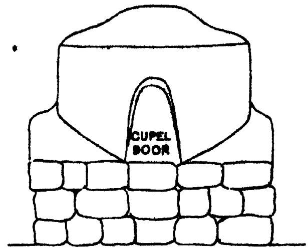

b Plan of Top



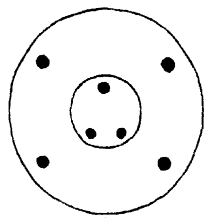

c. Section

FIG.—1. SQUARE CUPEL FURNACE

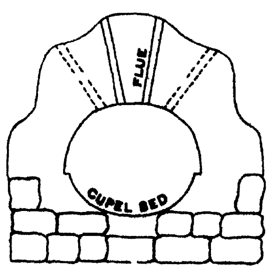
*Scale, 1 inch = 4 feet.*




a. Front Elevation




b. Plan of Top




c. Section

FIG.—2. ROUND CUPEL FURNACE

*Scale, 1 inch = 2 feet.*

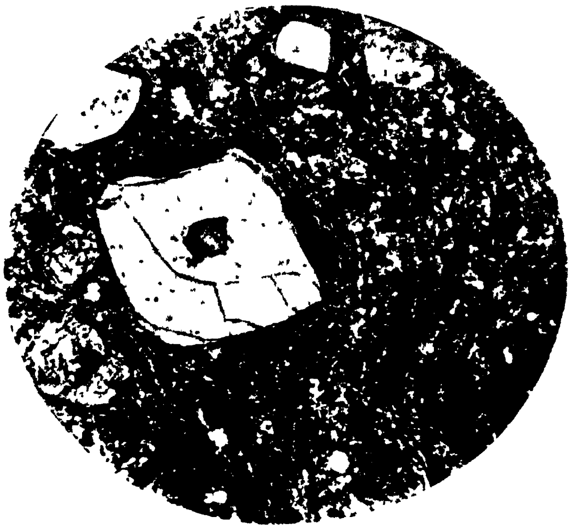


**Fig. 1**

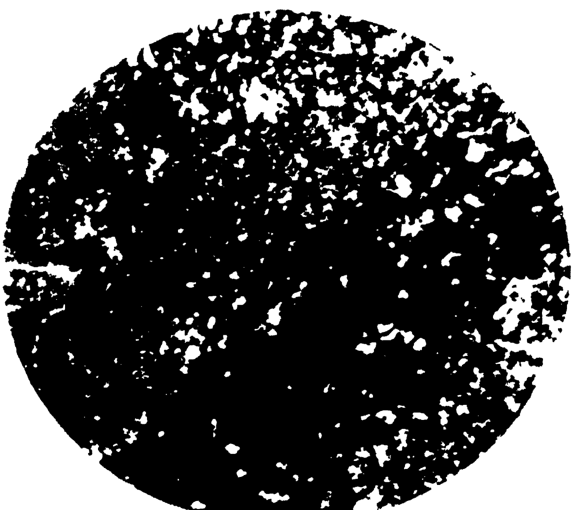


Fig. 2

**J. Coggin Brown, Photomicrograph**

***G. S. I., Calcutta***

Fig 1

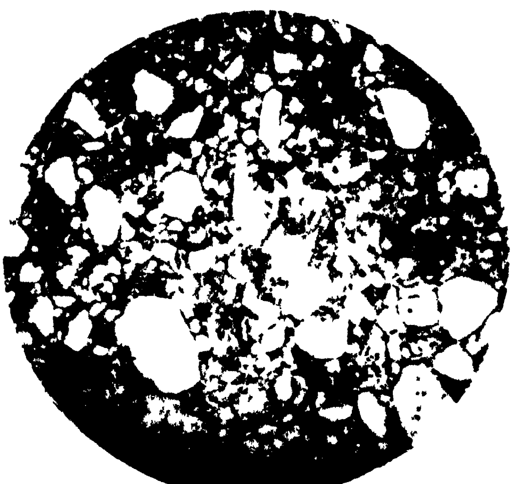
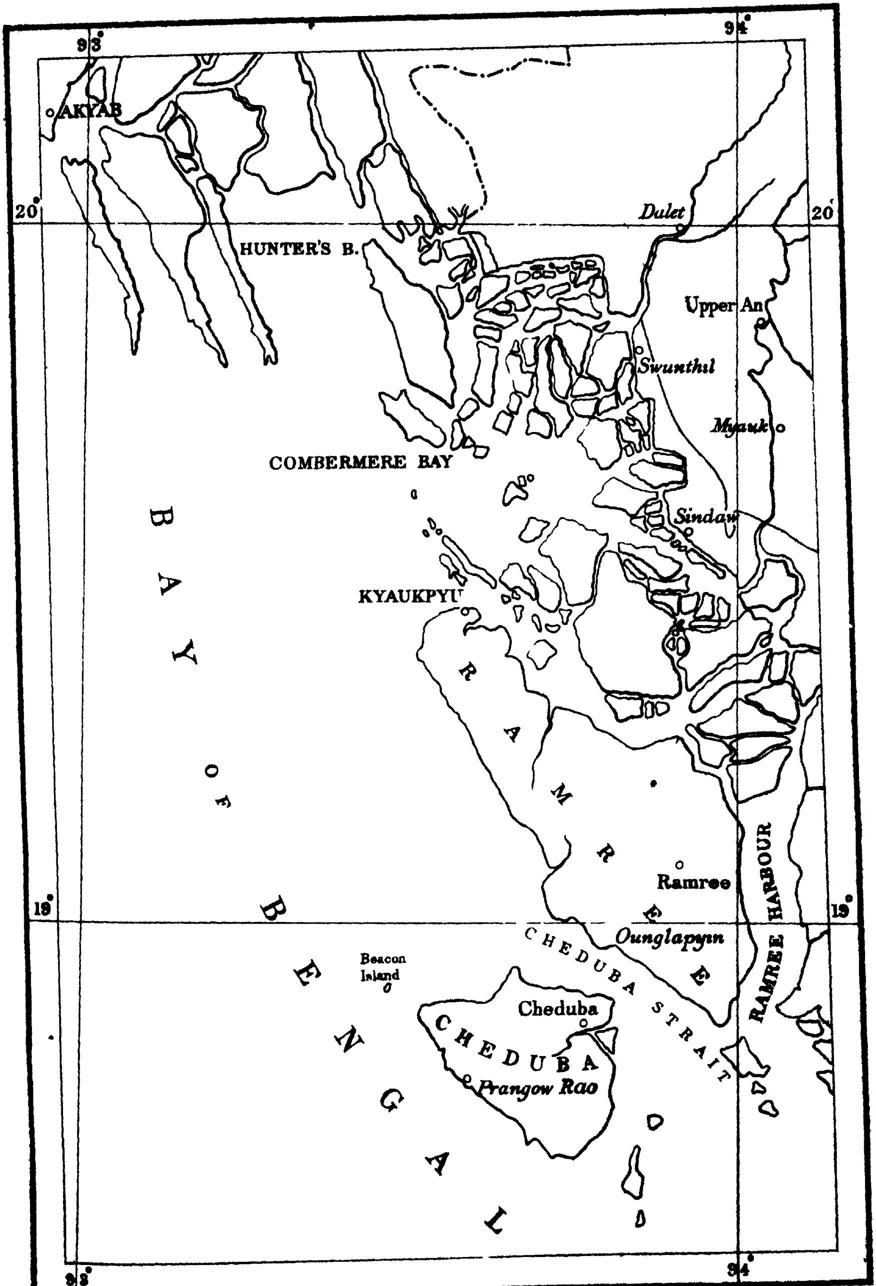
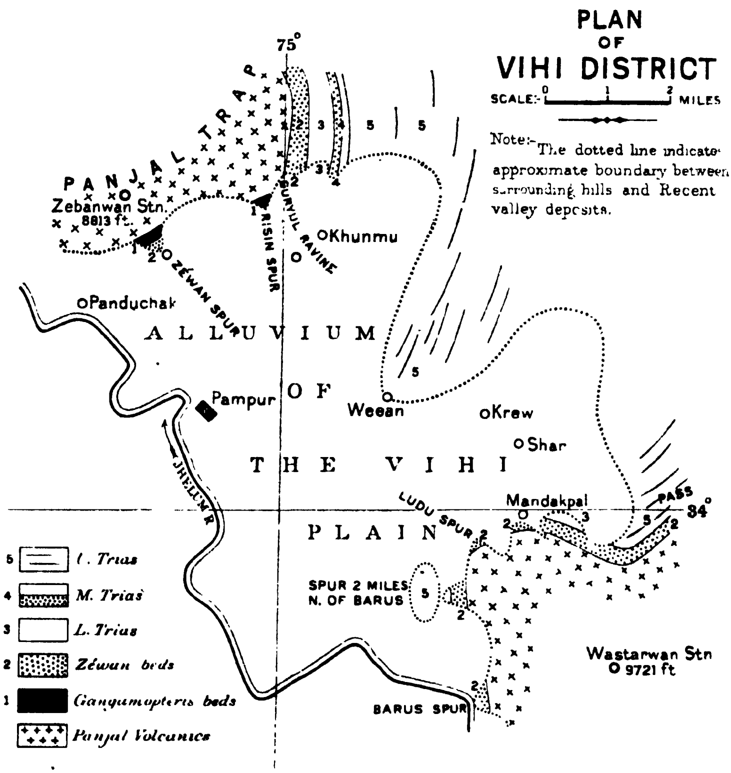


Fig 2

J Coggin Brown, Photomicrograph *G S I Calcutta*




MAP OF THE ARAKAN COAST AND PART OF THE BAY OF BENGAL.




*G. S. I. Calcutta.*